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THESIS

USSOCOM METRICS - A CASE STUDY IN MODERN C^4I NETWORK MANAGEMENT ISSUES

by

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June, 1997

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13. ABSTRACT *(maximum 200 words)*

Modern Department of Defense C^{4}I systems utilize high speed commercial computer networks, composed of commercial equipment and connectivity. The United States Special Operations Command (USSOCOM) SCAMPI (not an acronym) Network was a forerunner of this trend. Industry uses the same type of circuits but approaches the network management of these circuits from a financial interest versus the military strategic and tactical aspects considered by the service user. This thesis analyzes this representative network in the context of industry network management and metrics practices. The thesis first surveys and explains the industry practices most prevalent in this changing environment and then examines the practices in place at USSOCOM. The compilation of industry wide network management and metrics procedures is followed by a series of problem/solution recommendations for the SCAMPI network. These recommendations are explained in the context of current industry practices. This is followed by a series of emerging industry trends and technical developments which most likely will affect the implementation of network management and metrics tools. These developments are followed by a comprehensive industry definitions section, network bibliography, and a hypertext link guide to current military, industry and educational institutions networking solutions.

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USSOCOM METRICS - A CASE STUDY IN MODERN C^4I NETWORK MANAGEMENT ISSUES

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ABSTRACT

Modern Department of Defense C^4I systems utilize high speed commercial computer networks, composed of commercial equipment and connectivity. The United States Special Operations Command (USSOCOM's) SCAMPI (not an acronym) Network was a fore runner of this trend. Industry uses the same type of circuits but approaches the network management of these circuits from a financial interest versus the military strategic and tactical aspects considered by the service user. This thesis analyzes this representative network in the context of industry network management and metrics practices. The thesis first surveys and explains the industry practices most prevalent in this changing environment and then examines the practices in place at USSOCOM. The compilation of industry wide network management and metrics procedures is followed by a series of solution recommendations for the SCAMPI network. These recommendations are explained in the context of current industry practices. This is followed by a series of emerging industry trends and technical developments which most likely will affect the implementation of network management and metrics tools. These developments are followed by a comprehensive industry definitions section, network bibliography, and a hypertext link guide to current military, industry and educational institutions networking solutions.

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LIST OF SYMBOLS, ACRONYMS AND/OR ABBREVIATIONS

ADP	Automatic Data Processing
ASN.1	Abstract Syntax Notation - 1
ATM	Asynchronous Transfer Mode
B8ZS	Binary 8 Zero Substitution
BER	Bit Error Rate
BER	Basic Encoding Rules
B-ISDN	Broadband Integrated Services Digital Networks
C^4I	Command, Control, Communications, Computers and Intelligence
C4IFTW	C4I For The Warrior
COMSEC	Communications Security
CONUS	Continental United States
C/S	Client Server
DEC	Digital Equipment Corporation
DISN	Defense Information Systems Network
DITCO	Defense Information Technology Contracts Office
DMS	Defense Message System
DSCS	Defense Satellite Communications System
ESF	Extended Super Frame
FT1	Fractional T1 Line
GBS	Global Broadcast System
GOS	Grade of Service
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
IBM	International Business Machines Corporation
ICMP	Internet Control Message Protocol
IDNX	Integrated Digital eXchange Network
IP	Internet Protocol
IPV4	Internet Protocol Version 4
IPV6	Internet Protocol Version 6
ISO	International Organization for Standardization
JDISS	Joint Defense Intelligence Support System
JSOFT	Joint SOF
JTF	Joint Task Force
LAN	Local Area Network
MAC	Media Access Control
MIB	Management Information Base
MIT	Management Information Tree
MMI	Man-Machine-Interface
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NIPRNET	Unclassified but Sensitive Internet Protocol Router Network

NOC	Network Operations Center
NT	Windows NT Operating System
NMS	Network Management System
OO	Object Oriented
OSI	Open Systems Interconnection
PC	Personal Computer
QoS	Quality of Service
RFC	Request for Comment
RTT	Round Trip Time
RMON	Remote Monitor/Remote Monitoring
SCAMPI	Not an acronym The USSOCOM C4I Network
SATCOM	Satellite Communications
SHF	Super High Frequency
SIPRNET	Secure Internet Protocol Router Network
SNMP	Simple Network Management Protocol
SOCRATES	Special Operations Command Research, Analysis, and Threat Evaluation System
SOF	Special Operations Forces
SRC	System Resource Center
USSOCOM	United States Special Operations Command
T1	1.544 MBPS North American Digital Time Domain Hierarchy Standard
TCP/IP	Transport Control Protocol/Internet Protocol
UDP	User Datagram Protocol
VTC	Video Teleconferencing Circuit
WAN	Wide Area Network
WBEM	Web Based Enterprise Mangement

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EXECUTIVE SUMMARY

Modern C^4I networks utilized by the military are increasingly composed of commercial equipment and commercial connectivity. The number of users on most computer networks is growing exponentially. The number of hubs in each network is expanding geometrically. Within this explosive growth is the inherent problem of managing and measuring these expensive assets. Commercial networks are monitored and measured to meet corporate costing goals and guidelines. The DoD networks do not deliver a bill directly to each user, but seek to increase reliability, service quality and other variables.

This thesis is a case study of the network management and metrics measurement program of the United States Special Operations Command's (USSOCOM) SCAMPI (Not an Acronym) Network. SCAMPI is the principal C4I network for special operations forces. It covers the continental United States and Hawaii, and has deployable nodes in overseas locations. It was at the time of implementation a leading edge C4I network composed of optical fiber links and high speed hub switching equipment. It also had a later installation of a Network Operations Center (NOC) that conducts the network management and metrics measurements for the network. This center known as the Systems Resource Center (SRC), also serves in the classical trouble desk mode for all Automatic Data Processing (ADP) related problems. The SCAMPI system remains a robust and fully functional network. This thesis seeks to ensure that the network management and metrics program is proactive and allows constant improvements in service to the special operations community.

The thesis begins with an introduction to the SCAMPI network. This serves to acquaint any readers outside of the USSOCOM community with the fundamental network aspects that are addressed in the study. The next chapter serves as a network management summarization from many industry

sources. The area of network management is constantly changing, its standards are fluid, and the obsolescence cycle found in the computer industry is amplified by the change in all levels of computer network structure.

This thesis also seeks to consolidate the fundamentals of network monitoring, metrics collection, configuration control, maintenance, restoration, and accounting. This is done by the use of tables that provide more of a checklist approach to the task of ascertaining the merits of a planned acquisition or improvement. This also provides an overview of the primary elements found in most vendors Network Management Systems (NMSs). These sections are provided to enhance the understanding of later recommendations and solutions. The SCAMPI system is analyzed in the context of what network management and metrics functionality is present and utilized. The system is presented in terms of industry-wide terminology and practices.

A chapter is dedicated to the analysis of current NMS/metrics measurement limitations. Six problem areas are offered, each with an accompanying solution. The problems and solutions draw from the understanding of the previous industry fundamentals chapters. The implementation of these solutions all seek to increase the proactive role of the SRC in providing enhanced service to the user.

Following the recommendations chapter is a chapter on industry trends and practices that most probably will have an impact on the future of network management. These areas of potential complications to the network management problem are explained in the context of the technology and the possible benefits to the network manager/user.

In the interest of providing a single source document for the network manager/engineer/user several appendixes are provided with network management references and bibliographies. A glossary of networking terminology is included. A summary of hypertext documents that can be found on the

Internet in network management and metrics related areas is provided.

I. INTRODUCTION

A. MODERN NETWORK MANAGEMENT ISSUES AND CONCEPTS

1. Network Management and Metrics Principles

According to a Forrester Research study, the average 5,000 user corporate network costs more than $6.4 million per year to support. The increasing reliance on computer networks creates an accompanying rising support and management cost. This reliance also creates costs when a company faces a downtime on the network. Industry averages show this cost to be approximately $62,500 per hour of potential lost revenue. [REF 1]

Network monitoring has evolved from the tools and techniques that helped manage Local Area Networks (LAN's) to the large scale Network Operations Centers (NOC's) that can oversee thousands of nodes. Within this evolution, there have been many obstacles to the network administrators. Topologies of networks change rapidly due to the exponential growth of computer networks in the work place. Reliance on numerous manufacturers of computer network equipment to produce compatible equipment, while the standards of networking are constantly changing, has caused many difficulties.

The C^4I for the Warrior (C4IFTW) concept that currently guides the military's adoption of information technologies integrates commercial and military networks, and a mixture of system components to achieve connectivity. The provision of vastly increased access to information at all echelons is made possible by the use of modern high speed computer networks. This overarching doctrine has placed the procurement and deployment of computer networks into the mainstream of industry driven standards and procedures. [Ref. 2] The DoD

no longer sets its own unique standards and drives the market by volume purchases.

The interoperability, capacity, cost, security, and availability issues must constantly be addressed in all phases of a network's lifespan. In the design phases, acquisition and initial production, the issues of network management are usually secondary to the cost, capacity and production factors. Once a modern network is operational, the issues of network management and measurement of system resources through a dedicated metrics program becomes a higher priority. The establishment and management of such a program require the understanding of the interaction of the technological aspects of the network, the user requirements and the capabilities and limitations of a management system.

Once a network is operational, its status does not remain fixed. The normal growth curve of users in modern computer networks has been exponential. The bandwidth allocated to these users is usually a limited commodity and must be analyzed in the context of usage and future growth.

Network monitoring and management is difficult. Numerous variables and factors must be considered in the management plan. Differences in protocols, hardware variability and interoperability, incompatible operating systems, bandwidth allocations, and security requirements force a network manager to tailor plans that while operational today can be essentially dis-functional with any new additions or technology changes.

2. Fiscal Responsibilities of Network Management

The fiscal responsibility incumbent upon today's modern military manager requires the most effective use of resources balanced against military necessity. Network management systems allow the planning, measurement and monitoring of expensive network resources. The

predominance of commercial circuits that have a monthly lease fee based on bandwidth and service guarantees necessitates monitoring. The measurement of usage and performance to insure the service customer is getting what was paid for, and to wisely determine future requirements necessitates a usable and responsive metrics program.

A network in operation is a dynamic and chaotic process. The measurement of many diverse parameters are necessary to get a full picture of the state of the network. An example: Measurement of simple bandwidth allocations to individual users will only reflect problems when the users approach full capacity of their allocation. Unless a network is analyzed to see *who* and *what* is producing the flow of traffic and *how* it is managed and transported in terms of the dynamics of the network, much of the *future growth* indicators can be missed. Trend analysis and traffic studies give a good historical perspective, but reflect only the past usage of the network. Networks that are constantly growing, subject to rapid ramp-ups of activity in crisis situations, and not adequately monitored face potential complications.

A network consists of many dissimilar and technologically complex parts. The interaction of complex switching mechanisms and high speed conduits strives for a seamless and transparent system for the user. If a malfunction does occur, the priority on rerouting, and/or circuit restoration is high. The cost of impeded informational flow, while hard to directly account for in dollar amounts, is a serious cost to modern organizations. The ability of a network management system to alleviate any system outages increases the efficiency and value of the network. The further down into a network an automated system can detect and help repair assets the more cost savings can be achieved. Pro-active measures can often detect and repair network slowdowns or outages prior to customer notice.

3. Requirements for Modern Technology Concepts

Computer network management techniques have evolved with the explosive growth and proliferation of networks. The original equipment for network management was vendor specific and addressed the maintenance and management of a single or set of similar pieces of network equipment. The original LAN monitoring devices, capable of monitoring small scale operations within a segment of a network have grown to systems that can monitor devices on a world wide scale. The ability of a device to determine the status and operational capability of any of a multitude of network components has required years of industry attempts at standardization, compatibility and internetworking protocols. This evolutionary effort is still in an early stage. The industry is still maturing and with every new technological achievement, the obsolescence of existing standards is not only possible, but probable.

The "ever - elusive" state of the art in network management and metrics measurement requires the use of several modern computer technology concepts. These concepts include standardized and specialized network management protocols, and agent programs residing in managed network elements to perform delegated remote tasks. In addition the formal techniques of hierarchical naming and syntactical definition of communicated variables allow structured management functionality to exist at all network levels.

B. OBJECTIVE OF THESIS

1. Examination of SCAMPI System Metrics Program

The objective of this thesis is to examine a modern C^4I network, the USSOCOM SCAMPI, (not an acronym), network, in terms of Network Management and Metrics. The analysis of the existing Network Management and Metrics program in terms of procedures,

protocols, and metrics implementation will be undertaken. In addition to the basic examination of the system, the consolidation of industry practices that form the basis of network management and metrics application will be presented to gauge the performance criteria present in the existing SCAMPI system. This review will also serve as a condensed reference for anyone needing a quick survey on modern network management practices.

2. Recommendations For Improvements In The Metrics Program

Upon completion of this examination of the SCAMPI network, recommendations will be offered in terms of metrics program improvements and future network management innovations. It is hoped that this study will serve as a basis for further improvement of the metrics and network management process in this and similar DoD networks.

C. SCOPE, LIMITATIONS AND ASSUMPTIONS

The scope of this investigation is limited to the USSOCOM SCAMPI C^4I network but will have applicability in any modern C^4I network. The resulting metrics definitions, findings and recommendations will be delivered to USSOCOM upon thesis completion.

D. ORGANIZATION OF THESIS

This thesis is organized into six chapters. This chapter provides basic introduction, objectives, scopes and limitations of the work to be performed. Chapter II provides an introduction to the USSOCOM SCAMPI Network. Chapter III condenses into table form an industry wide survey of Network Management and Metrics. This chapter can serve as a check list for functionality on network management systems. Chapter IV covers the metrics implementation of the SCAMPI network. Chapter V provides initial recommendations and implementation for a pro-active metrics plan for USSOCOM. It examines metrics limitations

and network management shortfalls as currently configured, with recommendations for a pro-active metrics plan. It will discuss implementation and system requirements. Chapter VI explores the implications of near term technology innovations on network management and metrics and examines the basis for further research areas.

Appendices are provided to expand certain networking management concepts and to provide more detailed definitions of terms and concepts. In addition resources that are directly related to the topic but not cited in the reference section are listed. Network fluent readers will have less need of these than those readers new to network management and metrics. Appendix A provides USSOCOM Traffic study examples cited in the thesis. Appendix B provides additional and amplified network definitions. Appendix C provides a comprehensive bibliography of modern network reference sources. Appendix D provides hyper-text links to network management/metrics sites that are government and industry representative.

II. USSOCOM SCAMPI NETWORK ARCHITECTURE

A. SCAMPI SYSTEM DESCRIPTION

A brief overview of the SCAMPI telecommunications network is provided for those not familiar with the system. This description will acquaint the reader about those network features relevant to this examination of Network Management and Metrics measurement issues. For those readers familiar with SCAMPI, this chapter can be skimmed or skipped entirely.

Special operations forces (SOF) have unique missions that include direct action, strategic reconnaissance, unconventional warfare, foreign internal defense, and counter terrorism. The execution of these missions often requires communications and intelligence systems support that is distinctly different from that required by conventional forces. [Ref. 4]

SCAMPI , is a communications system that was created to allow dissemination of C^4I information between the United States Special Operations Command (USSOCOM), its components and their major subordinate units, and selected Government agencies and activities directly associated with the special operations community. [Ref. 8]

The SCAMPI network provides gateway service for the special operations community to external DoD classified voice, data and video teleconferencing (VTC) systems. Transmission of data between nodes of the SCAMPI system is over Defense Information Technology Contracts Office (DITCO) leased T1 and fractional T1 (FT1) lines. SCAMPI carries collateral and sensitive compartmented voice, data and VTC information. [Ref. 11, 17]

All information sent over the leased lines is fully secured using one or two levels of encryption. The embeddable KG-84 COMSEC Module (KIV-7) provides the encryption

mechanism for the network. [Ref. 15] No Multiple Level Security issues are covered in the context of this thesis. The issues of security as related to Network Management are reviewed in the functionality sections.

Numerous systems and applications ride on the SCAMPI network. HQ USSOCOM, USSOCOM component forces, and the USSOCOM Washington Office LANs are connected by SCAMPI to form a command LAN. SCAMPI provides connectivity for the SOCRATES, METOC and other special operations analysis tools used by the SOF community. [Ref. 4, 10]

B. SCAMPI NETWORK TOPOLOGY

1. Basic Informational Flow Topology

Figure 2-1 shows the basic network information flow topology for a single connection using the SCAMPI system and the gateway terminals [After Ref. 17]. Components of the topology are explained in the following paragraphs.

Ground Entry stations provide an interface for the SCAMPI network to allow an overseas extension of the information available on the basic network. These entry stations are primarily commercially manufactured satellite terminals that exist at DISN Terrestrial Gateway sites. The deployable SHF Tri-band Satellite Terminals that allow SCAMPI to have inter-connectivity on a world-wide basis operate on the C, X, and Ku band operational frequencies. The deployable packages include downsized electrical equivalent replacements for the 20-foot Quick Reaction Satellite Antenna. [Ref. 15] Defense Satellite Communications System provides the satellite channels necessary to relay the SCAMPI network to deployable nodes. The DSCS SHF SATCOM space segment consists of DSCS II and III satellite constellations with coverage areas ranging from 75 degrees North to 75 degrees south. [Ref. 4]

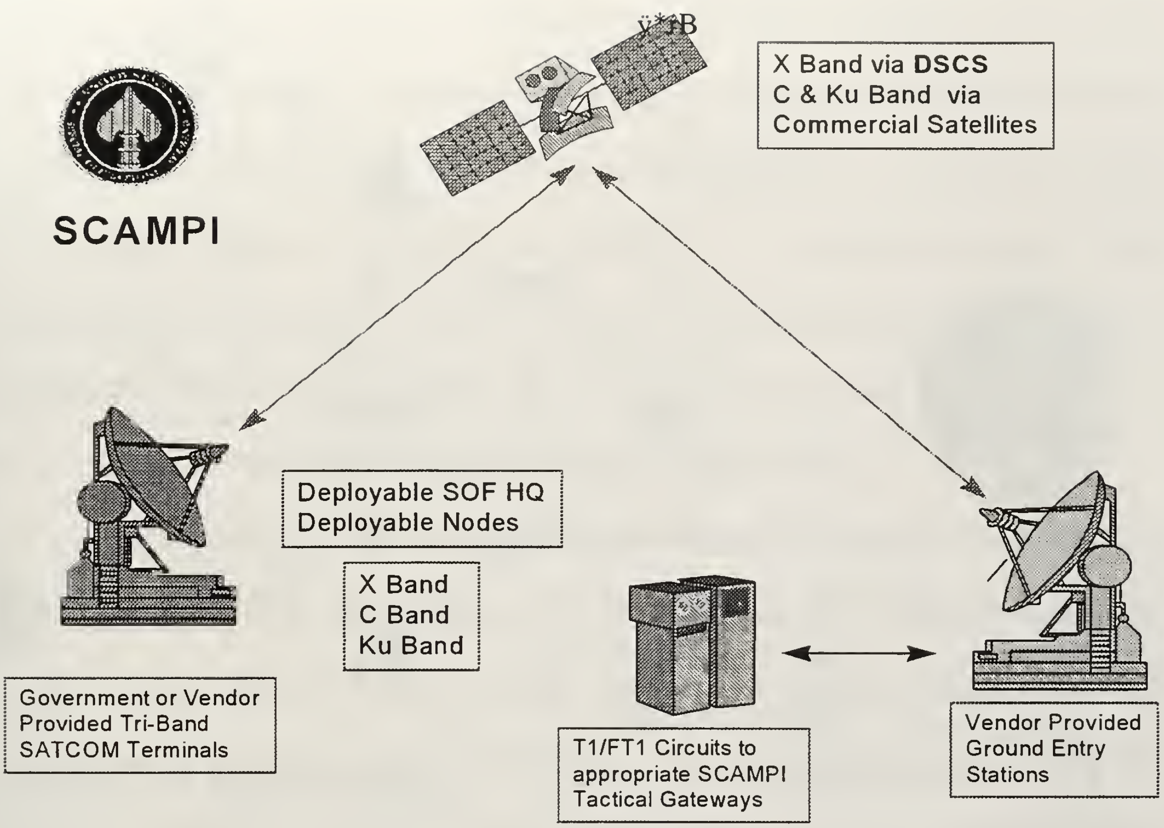


Figure 2-1 Basic SCAMPI Configuration

The ability to rapidly link the deployed SOF contingent with the connectivity and functionality of the SCAMPI network allows interoperability on a world-wide basis. The deployable SCAMPI nodes share the inter-connectivity of all other CONUS based nodes and the basis for network management and metrics still exists in this deployed status.

Figure 2-2 shows a notional diagram of the SCAMPI network.[After Ref. 17] It is provided to illustrate the types of internetwork connectivity, bandwidth, and nodal relationships that exist in the CONUS and deployed SCAMPI network. No geographical attributes of the system are labeled but the reader should understand that the system covers SOF organizations

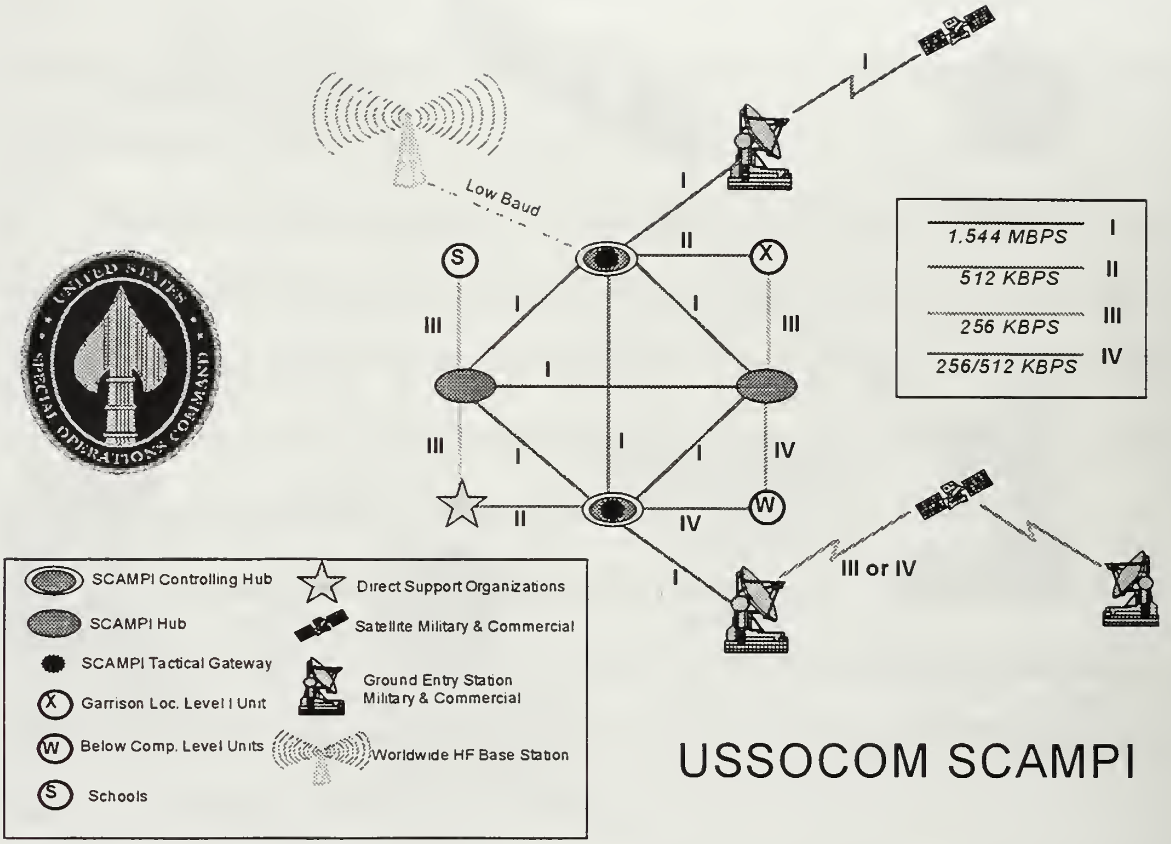


Figure 2-2 SCAMPI Hub Topology, Notional

on both coasts and multiple sites in the Southeast.

This network is specifically tailored to cover the special operations missions and support functions. SCAMPI is currently extended to over 35 organizations in the SOF community, and will be available for use by a Joint Task Force (JTF) and a JSOFT, as well as the special operator. [Ref. 17]

C. SYSTEMS READINESS CENTER (SRC) IMPLEMENTATION

The SRC serves as the Network Operations Center (NOC) equivalent in commercial

industry terminology. The SRC is located at the USSOCOM headquarters but allows management functionality to exist for the entire network, including pre-deployment checkouts on deployable SCAMPI Nodes. The SRC serves in the capacity of a 24 hour trouble desk facility. Any network or computer related problem can be referred to the center. Help operators, in addition to being able to answer questions on common workplace applications, can take information about a system malfunction and enter it into the tracking system. [Ref. 17]

D. SCAMPI NETWORK MANAGEMENT SYSTEM (NMS)

The SCAMPI SRC uses two NMS's, Network Equipment Technologies (NET) Open 5000 and the Hewlett Packard Openview. The NET Open 5000 is used to monitor the functionality of the IDNX 90's and other NET equipment. The HP Openview is primarily used to examine other elements of the SCAMPI network. The HP Openview is also extended by a third party application, Transcend®, which allows an enhanced examination and management of 3COM products. The ability to view graphical representations of a device and allow "virtual" manipulation of the network device such as allowed in Transcend is a feature common in modern network management tools. [Ref. 6,7,17]

III. NETWORK MANAGEMENT AND METRICS

A. NETWORK MANAGEMENT OVERVIEW

This chapter summarizes volumes of industry terminology and practices. The intent is to acquaint the reader with the fundamentals necessary to understand the problems and proposed solutions for network management and metrics implementation. The tables provided in this thesis will hopefully allow more of a checklist approach to be undertaken to measure the functionality present in any network management system that is being proposed or reviewed for completeness.

The industry practices that are condensed into table form are not present in all network management systems. Vendors emphasize different aspects and approaches to this very difficult problem. Vendors that produce network components structure their network management systems to favor and support aspects present in their components.

The networks management and metrics measurement systems are constantly evolving so this is just a snapshot of the state of the art at the time of writing. HyperText links to industry sources and network management/metrics sites are compiled and presented in Appendix D. The review of these and other online links by administrators and network engineers on a periodic basis is recommended to preclude the "18 month technological obsolescence cycle" which is even more pertinent to this field.

1. Network Management Systems (NMS's)

Network Management Systems in their simplest forms provide the basis for: network monitoring,-metrics collection, configuration control, maintenance, accounting, and restoration

[Ref. 9]. The basic purpose of network management is to automate the processes of monitoring and adjusting the performance of a network, as well as providing reports and measurements (metrics) of network activity. NMS's exist in differing degrees of complexity and sophistication. The amount of network management present in a network is usually dictated by several factors, including policy and budget. A large network is not always indicative of network management presence. Several large universities were examined in the course of research for this thesis and neither had any structured management system in place.

2. NMS Functional Management Areas

Tables 3-1 through 3-5 provide a reduction to tabular reference form, and facilitates a quick cross reference of each of the NMS functional management areas. These functions exist in differing degrees in different vendor packages. Different divisions and definitions of these functional areas exist with different vendors. The division presented here attempts to survey the field and include functionality from many different areas. [Ref. 21,22,23,24,25,26] Each table will have amplifying remarks following. All tables are organized into functionality areas on the left with representative and illustrative industry examples on the right.

The elements of the functional management area can be overlapping into several areas. For example, measures that can determine performance management can also be related to those in the fault management and restoration areas. The adaptation of measures in one area may also have unintended interactions in another. Examples might include: Security measures may slow performance, and fault management may occur at the expense of network throughput. The network engineer and administrator needs to consider the ramifications of such policies.

Table 3-1 details the elements and tasks performed in performance management.

PERFORMANCE MANAGEMENT	
Gather performance data on those variables of interest	Allows automated, selective collection, retrieval, storage and manipulation of data Metrics can then be generated for management decisions or automated network restoration NMS should be able to monitor, analyze and generate user defined reports on the metrics selected for use
Analyze the data to determine normal (baseline) levels	Benchmark levels are determined from normalized operational measurements and calculations on selected parameters
Determine performance thresholds for each variable	Allows establishment of alarms to alert/assist Network Operations Center (NOC) operators when values depart from preset thresholds
Simulation	Determine performance measures given differing configurations, routings, equipment line-ups, degradations
Tasks performed by performance management:	Monitoring and measurement of quality of service (QoS) parameters, detection of performance bottlenecks, QoS reporting, performance and capacity planning.

Table 3-1 Performance Management

Performance management exists in several categories. Depending on the monitored devices this can be as simple as determination of the status of the interconnecting links or as complex as advanced metrics. Advanced performance management can also enable pro-active methods. An often cited example of pro-active performance management methodology is network simulation. Network simulation can be used to project how network growth or changes in operational tempo will affect performance metrics. Network management packages can

include this feature as a standard application or allow the use of a "plug-in" simulation package. Analysis of growth and its impact on an existing network can be one of the most beneficial byproducts of simulation. Projected growth patterns observed by metrics can be applied to "what if" scenarios to analyze the performance of the network under projected growth factors.

Networks that are subject to greatly varying traffic loads, such as a military network, can use simulation to model and validate system capacity. Contingency planning and operations can stress a network's capacity compared to the relatively low level of day to day support functions. The ability to project the impact of a loss of a node in a battle or crisis situation is also an aspect that simulation can provide the military planner.

Table 3-2 details the asset/configuration management area:

ASSET/CONFIGURATION MANAGEMENT	
Monitor network and software configuration information	Tracking of existing network elements and their software licensing/application loadouts for ADP compliance Storage of all address and management information databases necessary to maintain, restore, or reconfigure the network
Autodiscovery	The ability to discover and map new additions to the enterprise network (within community string limitations)
Password protection (of NMS)	Prevent unauthorized changes to configuration
Tasks	Automatic documentation of configuration, resource configuration, remote configuration, administration of network history, initialization and monitoring of configuration operations.

Table 3-2 Asset/Configuration Management

A network consists of a number of resources that have to operate in a certain manner. Configuration management will combine and adapt resources in order to supply the requested system performance. Network configuration changes can have positive or detrimental effects on the performance, stability and availability of network assets. Derived metrics most always require the knowledge of numbers of users and allocated resources. Changes in network configurations that are not known to the metric process can produce very misleading metrics.

Network configurations can be maintained in configuration profiles. This type of structured approach allows a simplification in the deployment and evolution of facilities. An organization can utilize the system to facilitate software and firmware distributions as well as synchronizing the automated setup of network devices.

Auto-discovery is a feature that allows the system to constantly monitor and detect the presence of new assets from their internetwork communications. Generally auto-discovery is limited in its' search function by the community strings that are given it. These community strings are the "names" of the network segment that the NMS has selected for monitoring. [Ref. 9]

In commercial networks the asset/configuration management area provides the inventory and financial management of the network's equipment, facilities and software. The management area can compute the associated location, costs, vendors and warranty information. The support in computing costing of existing network elements and planning for future asset acquisition is enabled with this functionality.

Table 3-3 illustrates the accounting management areas and tasks:

ACCOUNTING MANAGEMENT	
Usage patterns	Determines ***where*** the traffic handled on the network is originated and in ***what*** quantities.
Usage quotas	Determines ***overages*** and ***underutilization*** of circuits to allow optimum fiscal and operational management
Resource utilization	Allows economic and performance analysis of existing circuits
Tasks	Monitoring of accounting data, handling of accounts, assignment of costs to accounts, supervision of quotas, accounting statistics

Table 3-3 Accounting Management

The primary purpose of accounting management, is to measure network utilization so that users of the network get their allocated service. The first step toward appropriate accounting management is to measure utilization of all important network resources. In a non-billed network, where users don't pay directly for their usage, the use of accounting management is best suited to ensuring optimal resource utilization.

Usage patterns and resource utilization require the ability to monitor origination and destination headings of traffic. Without revealing any of the content of the message the system needs to be able to track originations and successful deliveries of data. [Ref. 1]

Fault management is delineated in Table 3-4:

FAULT MANAGEMENT	
Detect, log, automatically fix (to extent possible)	The ability to execute pro-active network restoration routines Restoration routines often scripted and automated
Monitor activity and changes in network	Issue real-time alarms to NOC's Log all faults and alarms Test connectivity of all devices
Tasks	Monitoring of network status, reception and computation of alarms, fault diagnostics, initialization and monitoring of fault recovery, user support

Table 3-4 Fault Management

The primary aim of Fault Management is to detect, log and automatically restore network service. The ability to pro-actively and automatically reroute traffic based on a predetermined, controlled algorithm allows the least amount of down time or delay to a network user. If a system has suffered a catastrophic failure of major nodes the system may have to revert to a scripted restart of major components. If the system does not have fully automated re-route capability the system should give the operator assistance in manual restoration.

An increasingly used function of fault management is in the area of reliability analysis. [Ref. 24] While the NMS can be used in the troubleshooting and restoration mode, the analysis of the reliability characteristics of components ensures better system operation through prediction. This ability to conduct analysis places the system in more of a proactive mode that allows a higher quality of service to be achieved.

Fault management also overlaps the area of testing connectivity of the network. The metrics dealing with connectivity include the measures of availability of network interfaces, transmission characteristics such as transit time and delay, as well as the detection of error creating malfunctions.

Security management is outlined in table 3-5:

SECURITY MANAGEMENT	
Monitor access points	Primarily in unclassified networks but applicable in classified systems when using external networks
Identify sensitive network resources	Identification of threat potentials and the pro-active utilization of redundancy and automatic backup routines
Tasks	Access control, encryption of data, authentication, operation of security tasks

Table 3-5 Security Management

The primary purpose of the security management functionality is to provide for the definition, maintenance, application and enforcement of an organizations security policy. [Ref. 25] This should occur across the network, regardless of technologies or infrastructures. This becomes increasingly important as private networks are interfaced to external networks. The requirement to interface with the Internet and the SIPRNET adds complexity to the security management requirements of an organization.

In encrypted and closed networks this function is not generally handled the same as in un-encrypted networks that deal with internetwork connections. If however, a linkage to an outside network is enabled, additional security issues must be addressed and ensured.

Multiple Level Security implementation is currently a difficult problem for most DoD

networks. Pending technological advances and incorporation of the chosen solution, this problem remains unsolved. Multiple level security issues are not addressed in this thesis in the context of network management.

Table 3-6 provides an initial look at types of monitored events that can be handled by a network management system. [Ref. 5, 9, 25] These events can be the basis for metrics measurements and can provide troubleshooting aids to the NOC engineers.

TYPES OF MONITORED EVENTS:	
Number and state of its virtual circuits	This type of event includes auto-discovery related topology corrections. If GUI MMI present will be presented in topological format
Number of certain kinds of error messages received	Packet error messages,
Number of bytes and packets in and out of device	Typically from routers and node switches
Maximum output queue length (for routers and other internetworking devices)	Queued responses or trap messages
Broadcast messages sent and received	Error messages based on predetermined events or levels
Network Interfaces going down and coming up	Can be trap messages or reboot messages from switches

Table 3-6 Types of Monitored Events

3. NMS Attribute Characterization

Table 3-7 summarizes many of the industry wide characteristics of NMS's at the time of writing. [Ref. 21,22,23,24,25,26] These are generic and non-vendor specific unless noted.

ATTRIBUTES OF TYPICAL NMS's:	
Able to monitor large numbers and types of network devices:	Routers, hubs, concentrators, switches, servers, PC's, printers, etc. Increasingly ***any*** device connected to the network
Scalable	1000, 5,000 10,0000+ are typical values for the number of network elements (devices) able to be monitored and managed NMS Packages usually have pricing structures based on scalability limits
Enterprise-wide monitoring	Able to cover entire network and interfaces to other services Helps distinguish who has the outage - Internal or External to a network WAN coverage with LAN probe functionality
Use the IP-based SNMP Protocol and RMON extensions to monitor most types of network elements	If not using SNMP will use CMIP or SNA or similar standards.
Non-vendor specific	Allows a single NMS to service an entire non-homogenous network May require 3rd Party plug-ins to monitor some devices
Provide a platform on which third party applications for the monitoring of specific devices can be run	Example 3COM Products - Transcend
Runs under UNIX or NT, and can be extended so that locally developed and commercial server processes can be monitored	Typically on a Work Station, with dedicated usage and sufficient hardware and memory resources
Allow an operator to use graphical tools to do ad hoc inquiries about the state of devices on the network	As in HP Openview and Transcend

Table 3-7 Attributes of Typical NMS's

These baseline functional attributes are typically included in most NMS packages with additional options and vendor specific plug-in packages available.

A consolidated table of NMS functionality is provided in Table 3-8. [Ref. 25, 27]

Management Function	Description
Object Management	Create, delete, examine, and update objects; report that such manipulations have taken place.
State Management	Monitor object's management states; report when these states are changed.
Relationship Management	Establish, monitor, and view the relationships among objects. May also include the auto-discovery capability to discern new additions to a network.
Alarm Reporting	Provide notice of and information about faults, errors or other network abnormalities.
Event Reporting	Select events to be reported; specify the destination of reporting. Distributed management levels may require multiple reporting destinations.
Security Alarm Reporting	Provides notice of security alarms set by: improper procedures, illegal entry attempts, can include physical entry if tied into the network reporting.
Security Audit Trail	Provides ability to reconstruct events and procedures that were used in a improper or illegal entry attempt or measure
Log Control	Handles event logs, log events, and allows creation of new logs.
Access Control	Controls access to networks, applications, and data

Table 3-8 Consolidated NMS Functionality

B. NMS STRUCTURES

1. Managed Objects

Network management models are built around managed objects, which are any network elements that can be used or monitored. These models generally specify the kinds of attributes managed objects must have and the kinds of functions associated with them. A network management configuration generally involves a managing process, which runs on a managing station. The managing process collects performance and other data about the network or about particular nodes on the network. This information is actually gathered by managing agents, which are programs that monitor workstations, PC's, printers, or any other network device, and that can report this information to a managing process. The details of this monitoring and reporting process help distinguish different network management models. [Ref. 9]

Network management is generally implemented as a high-level application, so that the management software uses well-established protocol suites, such as the TCP/IP protocols, to do its work and to move its information around. Various models have been proposed for network management. The two most comprehensive proposals are the models developed for the Internet Protocol (IP, or TCP/IP) and for the ISO's seven-layer OSI (Open Systems Interconnection) model. In addition, major network management packages still rely on mainframe-based management models, such as those developed by IBM, DEC, and AT&T. [Ref. 9] A typical NMS system is shown in Figure 3-1.

This figure shows a typical first generation NMS enhanced by a proxy server. [After Ref. 9,21] The functionality shown is purposeful to match the studied NMS in this thesis.

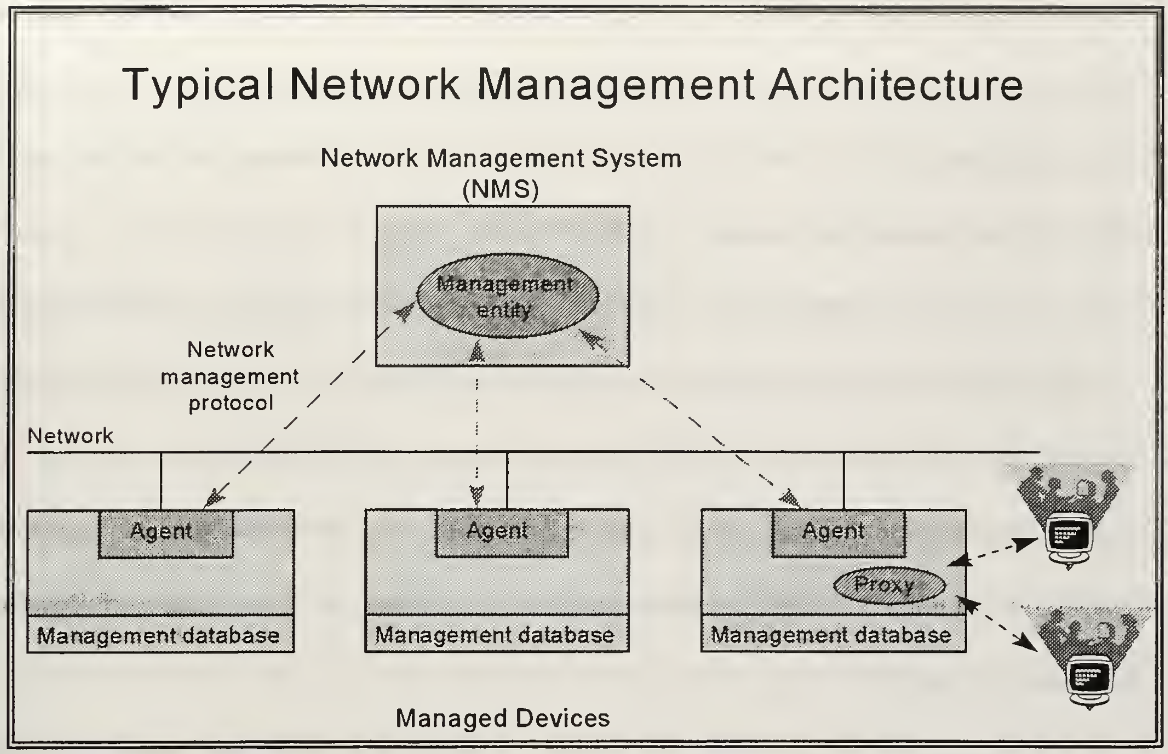


Figure 3-1 Typical Network Management Architecture

2. Network Management Station Software

The network management capabilities are usually implemented in software. The management tools may be specialized (for example, collecting just performance data) or comprehensive. Tools must have monitoring, reporting, and analysis capabilities. Those tools that will serve as managing processes as the control programs for the network management also need control capabilities. In general the management models do not specify the details of how these capabilities are to be implemented. For example, programs may report data in text or graphics form.

Programs will also differ in their monitoring capabilities. The tools may be designed for Local Area Network (LAN) or Wide Area Network (WAN) management or both. Although

many of the tasks are the same for managing both LANs and WANs, there are some important differences, mainly with respect to reporting and timing. Management tools that are designed to manage both LANs and WANs are sometimes known as Super Managers, and they are part of even more comprehensive architectures.

An agent is a software process (daemon) running in a remote device. It is an embedded process which monitors the activity of the device's interfaces and stores all the information that is monitored into system memory that can not be cleared until the device is re-powered. The information that is gathered is placed into registers that correspond to variables of interest to the SNMP process. Each device in the network has a separate and distinct set of management information. [Ref. 9]

An agent is hosted by the device and is dependent upon the device being operational and functional to allow communication back to the NMS. SNMP agents monitor the desired objects in their environment, package this information in the appropriate manner, and ship it to the management station, either immediately or upon request.

In addition to packets for processing requests and moving packets in and out of a node, the SNMP includes traps. A trap is a special packet that is sent from an agent to a station to indicate that something unusual has occurred. This information follows a predetermined format and procedural occurrence. [Ref. 9]

3. NMS Protocols

Network management protocols are usually either, the SNMP of the Internet Protocol Suite (TCP/IP) widely used in data networks, or the ISO CMIP for use in public telecommunications networks. [Ref. 9] The protocol that is applicable to this study and thesis

is the SNMP and any extensions of the basic protocol.

4. Management Information Base (MIB)

The data communicated between the Network Management System (NMS) and the managed entity (agent) are formally defined as object classes in a Management Information Base (MIB) or Management Information Tree (MIT). The format is the Abstract Syntax Notation - 1 (ASN.1) and is encoded for transport using the Basic Encoding Rules (BER).

The implementation of the agent is dependent on the device in which the agent will reside. The vendor of the device usually is responsible for any implementation of Network Management functionality. As long as implementation of the agent is compatible with the standard protocol, MIB or MIT definition and encoding conventions the agent will be manageable by the NMS. [Ref. 24]

Open applications and extensible agents need not be written in the same language. While NMS applications are "open" and can be modified for increased functionality and extended to manage more agents, the agents are usually closed systems and generally cannot be modified. If an entity is modifiable, the amount of system assets available to management functionality usually is very small. Many managed entities lack the ability to be directly managed in either the SNMP environment.

5. Remote Monitoring (RMON)

Devices that traditionally have been employed to study the traffic on the network are referred to as network analyzers, or probes. These monitors operate in a "promiscuous" mode, viewing every packet in the circuit to be analyzed. These devices can be located in any type of network, with the location determining the level at which they monitor. PC's with a RMON

program can monitor LAN activity. Routers can have RMON probes attached or have imbedded functionality. [Ref. 24]

The monitor produces summary information, including error statistics, such as counts of undersized or oversized packets and number of collisions. Performance statistics, such as number of packets delivered per second and packet size distributions can be determined by this form of monitoring. There are many metrics that are unattainable without the presence of a RMON device. The misplaced concern for security of traffic has caused many a manager to not be able to adequately configure probes in the network. The address headers of packets, not the content of the message, is what is important to read and measure.

6. Network Management Standards

Networks are very heterogenous in composition. Multiple vendors coupled with only Requests for Comment (RFC)'s for industry "standardization" allows a wide variance in the implementation of network functionality. In the area of network management implementation this variance reflects industry trends. Technological changes produce legacy elements that while still useful for task production may not communicate well with newer management systems. The constant moving target of industry standardization has produced several versions of each standard. SNMP is currently SNMP v.2, MIB is currently MIB II, etc. Each new manufacturing cycle institutes current standards but may not include backwards compatibility for all functions. [Ref. 9]

C. METRICS

1. Metrics Functionality

The ability to collect metrics, or measurements of network performance, exists through

the Network Management System's (NMS) functionality. Each element of the network, that has network management functionality embedded in it in any form, is capable of storing and reporting events that when processed and analyzed can produce metrics. These metrics are dependent upon the ability of the NMS to provide tasking as to what is to be collected, what is reported, when is it reported and what aggregate of time does each reporting period cover. [Ref. 21] Without a managed plan of metrics measurement most organizations are limited to simply measuring the availability of circuits and possibly their allocated bandwidths.

Any network element that is not SNMP functional may have metrics gathered on it by a related or close proximity element that is operational. An example of this would be in a LAN in which not every device contains an agent but the server serves as an" intelligent agent" and reports on all the devices in a LAN sub-segment. Distributed management functionality such as this instance is not always present in some Network Management implementations but rather have only a single station that polls all elements.

Metrics also have to tailored to the management objective. The simple flow of traffic through a network element will produce any set of management statistics that are requested. If the statistics measured, recorded, stored and then forwarded do not match the management objective the effort is wasted. [Ref. 9, 21] The NMS and metrics process also adds to the total network traffic. The aim of most systems is to make this process very transparent and insignificant in terms of network statistics.

The ability to accomplish all metrics functionality does not exist in the SNMP or CMIP protocols. Vendors have been producing extensions that seek to better measure functionality of their devices and applications [Ref. 24]. Any structured metrics program will have to make

decisions on the management objectives, the implementation structures and strategies, and the cost basis of this effort. The levels of management reporting and the detail of information required directly impact the overall metrics schema. Metrics are measurements of a process. The concept of metrics encompasses all industries and professions. Metrics will be used in this thesis to mean a measure of a network process.

2. Types of Metrics

In industry practices, two types of metrics are generally categorized and defined: formal and empirical [Ref. 1]. Each will be examined in the context of network management.

A Formal Metric is one that views a component in terms of its abstract, mathematical properties. In terms of a network this would emphasize viewing network properties in analytical terms. Two examples of a formal metric:

a) Bandwidth of a physical link:

A links maximum data-carrying capacity, measured in bits per second.

b) Buffer size of a router:

How many bytes the router has available for buffering queued packets. In practice this might be specific to the outgoing interface, or it might be shared between the different interfaces, or it might be different for different flows or types of flows. These differences are crucial, and illustrate some of the difficulties of devising well-defined formal metrics.

Empirical metrics correspond to properties that are generally too complex to discuss analytically but are still very important for practical measurement. These metrics are generally defined directly in terms of a measurement methodology. When confronted with complex systems measurement, many measurement communities have used the *benchmark* approach,

in which some standardized applications are used to stress a system, and the system's performance in executing the benchmark is then used as a metric for how well the system performs in general.

3. Network Metrics in Commercial Networks

The general usage of metrics measurements in commercial networks divides the measurements into four categories: 1) Utilization metrics, 2) Performance metrics, 3) Availability metrics, and 4) Stability metrics. [Ref. 9, 24]

Table 3-9 shows representative metrics categories that are found in commercial network management/metrics packages. This is a collection of metrics examples and does not directly correspond to any given vendor.

Metric Category	Metric examples:
Utilization	- Total input and output packets and octets - Various Peak metrics - Per protocol and per application metrics
Performance	- RTT metrics on different protocol layers - Numbers of collisions on a bus network - Number of ICMP Source Quench messages - Number of packets dropped
Availability	- Line availability as percentage of uptime - Route availability - Application availability
Stability	- Number of fast line status transitions - Number of fast route changes (route flapping) - Short term ICMP behavior - Next hop count stability

Table 3-9 Metrics Categories

IV. SCAMPI METRICS IMPLEMENTATION

A. SCAMPI METRICS DESCRIPTION

The SRC serves the NOC role in the SCAMPI Network. The metrics program that has been implemented tracks what would be broadly termed in industry as performance metrics. These metrics are utilized to fulfill troubleshooting and management functions.

The data to verify performance metrics at USSOCOM is gathered at the Systems Resource Center (SRC) [Ref. 6]. Performance metrics are divided into two main categories: system metrics and circuit metrics. The SCAMPI system metrics include Mean Time Between Failures (MTBF), Mean Time to Repair (MTTR), bandwidth utilization and system availability. [Ref. 7,17]

This performance metric measurement is utilized to ensure contract compliance by the long haul carrier network provider. The performance measurement of the T1 and fractional T1's (FT1) is conducted in the SRC using the Integrated Digital eXchange (IDNX) Network Management System (NMS) 5000 which monitors the IDNX 90's located at principal hubs. All contracted T1's are provisioned for extended superframe format (ESF) and Binary 8 Zero Substitution (B8ZS) coding. ESF allows the government and the contractor a nonintrusive monitoring capability that is used to measure the link and node performance of the SCAMPI network. [Ref. 8]

B. PERFORMANCE METRICS

This summary illustrates the nodal metrics measured on SCAMPI. These tables borrow heavily on the early work of the MITRE and GTE representatives on staff at USSOCOM and

are recreated to give an understanding of the current methodology utilized for metrics calculations by SCAMPI engineers. The metrics found in these tables do not necessarily match the industry definitions given in the previous chapter but do provide a structured basis for measuring the network. [Ref. 6]

Table 4-1 provides the metrics applied against the network to determine Mean Time To Repair (MTTR) and Mean Time Between Failures (MTBF). These metrics are measured and derived by tracking the T1 and FT1 circuit statuses. Human observation and consultation is present on the determination of times.

Metric	SCAMPI Standard
Routine Nodes MTTR - (Hours)	½ hour at manned sites during normal working hours 4 hours at manned sites after normal working hours
Critical Nodes MTTR - (Hours)	½ hour 24 hours/day
All Sites MTBF - (Hours)	280 hours
All Sites Availability	98%

Table 4-1 SCAMPI Nodal Metrics

Table 4-2 examines the SCAMPI Circuit Performance Metrics including circuit availability, bit error rate (BER), errored seconds and severely errored seconds. These parameters come from the monitoring of contractual compliance of the long haul carrier. The basis for these metrics includes human observations and resolutions of fault during outages.

Metric	SCAMPI Standard
Availability	99.95% (operational efficiency)
BER	1×10^{-7} (Contractually 10^{-6})
Errored Seconds	Fewer than 8% of one-second intervals to have any errors. (Equivalent to 92% error free seconds)
Severely Errored Seconds	Fewer than 0.2% of one-second intervals to have a BER worse than 1×10^{-7}

Table 4-2 SCAMPI Circuit Metrics

Circuit Availability Metrics are presented in Table 4-3.

Metric	Data Source	Calculation	SCAMPI Standard	Notes
Circuit/System Availability	CSU (Primary) NMS-5000 (alternate)	[uptime/(uptime + downtime)] x 100%	99%	O&M contractor calculates and provides info to SRC. Outage responsibility assigned by SRC.
BER	NMS-5000 BER Report	No. of errored bits / Total No. of bits	10^{-7} CONUS 10^{-6} OCONUS	Predetermined NMS-5000 Report, SRC
SLIP	NMS-5000 Trunk Frame Slip Report	Internal to NMS-5000	Not specified	Predetermined NMS-5000 Report, SRC

Table 4-3 Circuit Availability Metrics

C. DERIVED METRICS

The derived metric measurement and calculation is divided into the areas of: load forecast and Grade-of-Service (GOS).

Derived metrics are determined by analysis of network operational data. This process requires interpretation of collected data. They are derived from network usage statistics and information obtained from Integrated Digital Network eXchange (IDNX) and HP Open View LAN manager software.

1. Load Forecast

Load forecast is based on the current SCAMPI user demand. Bandwidth allocation is set for each user. Load forecast trend data is used to project growth requirements. An example of load forecast is shown in Appendix A.

2. Grade-Of-Service (GOS):

GOS is divided in to voice and data subcategories, and is based on available service.

D. TRAFFIC STUDIES AT USSOCOM

Appendix A. contains representative traffic studies at USSOCOM. The one that are included are purposely aged, not specific to any real world crisis and respective of the limits of the USSOCOM SCAMPI classification guide.

The inclusion of the studies is to illustrate the state of the art, the existing basis of metrics and to offer and illustrate recommendations based on selected examples. Further reference to the studies in the recommendations chapter will be used to illustrate limitations.

V. CURRENT NMS/METRICS LIMITATIONS

A. STATE OF THE ART NETWORK MANAGEMENT PROBLEMS

The inherent problem with any assessment of a system is that while it was state of the art or ahead of the art at the time of installation, time and industry strides can bypass its treasured status. The USSOCOM SCAMPI Network remains a highly reliable, efficient network in its present form. The design and utilization of T1 capable fiber optics and reliable high speed hub switching systems has allowed the QoS and design parameters to be met and maintained.

The recommendations offered here are intended to solicit improvements and changes to maintain its preeminent role in serving the SOF community. Each problem will be stated and then a proposed solution will be offered. These problem/solution sets are just a starting point and will require investigation into the implementation of each in the context of the total management of the network. As with most aspects of network management, Solutions that are offered have interactions and cannot, be considered separately.

The recommendations are then consolidated and placed into table format. The table form shows interactions of the recommendations and implementation factors. It is followed by an assessment of the recommendations and the functional management areas covered earlier in the thesis. This form was chosen to maintain the consolidation "checklist" approach adopted in the industry survey section.

B. PROBLEM 1 AND RECOMMENDATION

1. Problem: Centrally managed NMS topology, inability to adequately poll from central point without overloading system.

In USSOCOM, the NMS is centralized and all functionality exists in very few workstations. This is the normal topology of early network monitoring systems. The scalability of the SCAMPI network has followed the normal exponential growth curve thus aggravating the centralized network management/measurement approach.

The polling rate and the large number of individual SNMP capable devices in a growing network will generally preclude the utilization of a single or small number of workstations to adequately poll and collect responses from a single location [Ref. 23,25]. If there are thousands of devices on the network, the percentage of traffic related to just insuring network presence can become unacceptably large. Polling rates of the SCAMPI network have been purposely held low through programming and most SNMP calls to devices reflect the SRC's role in troubleshooting [Ref. 6].

Reliability and redundancy issues in a high priority network could also lead to the question of: "Why a single point failure of the SRC could allow critical network management functionality to go unaccomplished?" This issue coupled with the offered solution seeks to eliminate that possibility.

2. Solution: Distributed managerial presence in the form of C\S at each major Node to encompass the LAN/WAN management.

The requirement to segment the network and distribute the managerial functions seems necessary. The industry trend of Client-Server distribution of data base servers can form the basis of this type of functional distribution. By distributing servers, the workstation doing the

polling can be topologically closer to the devices which it manages. This reduces traffic, particularly traffic through WAN T1 lines from and back to the SRC. Multiple small servers will generate less traffic overall than a single workstation polling all stations from a great distance. Each server will contain the network information, MIB's, RMON Tables for each network section in it's cognizance.

The primary argument against such a measure as this is that it will have costs associated with the allocation of servers and programming to perform this function. The cost differential of having this monitoring function performed on a distributed basis on existing assets, with a higher degree of network monitoring being possible offsets the implementation cost.

The ability to transparently view and navigate the distributed servers from either the SRC or an alternate viewing point seems very beneficial. Two looks at a single failure can give the SRC a better idea of the real solution. This functionality in the monitoring of T1 line availability is done with personnel at key nodes and the benefits of dual looks is demonstrated there. Another aspect of distributed servers is the aspect of network restoration. In a centrally structured NMS system any scripted, or manual, network restoration effort will be essentially sequential and incurs the wait time for processing serial events.

LAN managers present in the distributed nodes of the USSOCOM network do many similar functions to the distributed C/S described in this solution. The ability to examine this data in the performance of WAN network management seems not to have been exploited thus far. A C/S distributed system should help facilitate the incorporation of LAN specific measurements into the overall NMS plan.

C. PROBLEM 2 AND RECOMMENDATIONS

1. Problem: SNMP/RMON Limitations, inability to adequately measure network devices for baseline performance.

SNMP provides details about network devices with an SNMP agent--a router interface, for example--but it won't produce any data about other devices on the network, such as the end nodes that communicate over that router interface. Even if every device you wanted to monitor had SNMP, it would be impractical to poll them all to correlate data and extend your baseline's reach. SNMP is quite effective for configuring and managing devices, but it doesn't generate the high level of performance detail that good traffic base-lining requires. [Ref. 21]

SNMP depends on polling of network devices to determine the content of network management data. RMON presents a standard way to gather performance data from LAN devices and reduce SNMP polling [Ref. 9]. But it has several drawbacks: it's LAN-centric; it provides only Media Access Control (MAC)-layer information; and it can't correlate traffic to expose end-node conversations, or tell which applications are generating the traffic.

RMON version 2 addresses some of these limitations but unfortunately remains LAN-centric. It's also very processor-intensive, driving up the per-managed-segment cost of RMON probe [Ref. 9]. As a result, the WAN continues to be a “black hole” in terms of ability to be measured and managed. To remedy this, many vendors manufacture WAN probes that use proprietary RMON management information base (MIB) extensions to track WAN utilization, errors and other critical statistics. [Ref. 23,24,25,26] Since we don't have a standard MIB to assess these functions, this becomes a sensible approach.

2. Solution: SNMP/RMON Probes And WAN Network Monitoring

RMON probes cost money. Lack of probes cost money and create inefficiencies. The

decision becomes whether the network will or won't be monitored to produce proactive measures that insure better service for the user. There are usable, viable industry utilized metrics of performance that currently can not be measured or analyzed at USSOCOM. The current system cannot be modified with just software packages to provide this functionality.

In a similar effort to this recommendation, the JWID 97 network evaluation and assessment effort includes some elements of this type of monitoring. Their plan uses RMON probes to analyze some content of the traffic being passed on selected high speed networks that interconnect the JWID demonstration systems [Ref. 28]. This recognition that the content analysis of traffic, as to the applications, protocols, and mixtures of traffic is *fundamental* to the accomplishment of effective network measurement and management provides further impetus to include this solution.

D. PROBLEM 3 AND RECOMMENDATIONS

1. Problem: Non-Monitoring of Traffic as to analysis of application, protocol

The monitoring of application and protocol related traffic indicators can reveal problems that otherwise can go undetected. Examples of this could include: protocol mismatches, incorrect routes, broadcast storms and even some low level denial of service attacks.

A normal question to the network manager as to what percentage of traffic during an event was related to a certain user, set of grouped users, certain protocol or application can be exceedingly difficult if the system lacks this ability. While systems were originally set up to handle telephone calls and "data," the mixing of content and changes in the way information is being generated and handled has changed the percentages of traffic content.

See Appendix A examples 1-6. These traffic study examples are representative of USSOCOM network loads. Some circuits have very dynamic and widely varying loads while others have allocated bandwidth and low usage. What is happening when the traffic load peaks or bottoms out? Is there a network related malfunction occurring? Is there a contributing factor such as a protocol mismatch? Is this circuit fulfilling the task for which the bandwidth allocation has been slotted? Unfortunately there is no current methodology in place to answer these questions. These questions and any associated metrics are essentially unattainable.

2. Solution: Institute application and protocol monitoring capability

The monitoring of the traffic application and protocol layers does not have be a full time, full enterprise-wide function. The required assets and monitoring equipments are initially best dedicated to problem areas and to proactive discovery of potential problems. New segments of a network could have dedicated testing in the initial "burn-in" phase. Older network segments that have experienced symptoms of BER, unexplained interruptions and outages, or other non-explained problems are also good candidates for this type of monitoring Once the performance and training aspects of the introduction of this capability are determined the capability can then be incrementally spread to critical nodes and left in place.

E. PROBLEM 4 AND RECOMMENDATIONS

1. Problem: Pro-active vs. Reactive Mode of Operation

A NMS that is only utilized in the role of troubleshooting after a network failure, or monitoring and recording past events, lacks the ability to pro-actively analyze and react to traffic overflows, system malfunctions or even low level system attacks.

2. Solution: System monitoring that detects, analyzes and reacts to network malfunctions, as they are happening.

Implement a proactive NMS. This can either take the form of an additional software package that supplements the existing system, or less prudently a stand alone system.

F. PROBLEM 5 AND RECOMMENDATIONS

1. Problem: Interoperability Of NMS And NT systems

Within the last few years most industry organizations have seen changes in individual operating systems (OS) and platforms with a pronounced shift to include more and more of the Microsoft Windows NT OSs. This OS shift has also been prevalent in the military. It has been stated as a standard under some CINC's plans, such as USPACCOM's Information Technology for the 21st Century (IT21). In addition the proliferation of NT servers at all levels of the organization has created a new dependence on these cheaper C/S systems. The migration of such systems as the Joint Defense Intelligence Support System (JDISS) to NT's exemplifies the trend of workstation applications being ported over to the personal computer realm.

The ability of a NMS to effectively monitor and utilize information from this rapidly increasing sector of the network needs to be addressed. The inability to directly access and utilize this information currently exists at the SRC. The amount of information and network management capability that can be added to the SRC's capacity will increase as the proliferation of NT machines continues. The current capability that exists in the SRC with respect to NT machines would be to treat them as network objects, assign SNMP functionality and then poll them with respect to presence and rudimentary operation.

2. Solution: Windows NT and Systems Management Server integration

Any interaction with NT systems, particulary with the NT as a server needs to follow

the philosophy of intelligent agents and ensure that the server (the agent) monitors event thresholds and other events and then reports SNMP traps to the cognizant C/S node.

An enhancement to the NT server, the Systems Management Server (SMS) provides automated software and hardware inventory, software distribution and remote diagnosis capabilities. Departing from LAN functionality it also allows integration with leading enterprise management systems. The inter-connectivity with NMS systems such as the HP Openview found at USSOCOM is cited as a common industry standard. [Ref. 29]

Advantages that can be achieved by this solution additionally consider the LAN/WAN divisions and concerns addressed in recommendation one. The abilities inherent in the NT servers to measure and monitor these functions as well as providing a viable platform extension for multi-vendor network components.

G. PROBLEM 6 AND RECOMMENDATIONS

1. Problem: Lack of Network Simulation

The ability to model existing networks or sub-segments, and conduct "what-if" scenarios is a basic capability that most modern network management systems consider essential [Ref. 3, 21] The capability to automatically integrate auto-discovery included topology elements into the database and modeling algorithms allows new network additions to be timely considered in subsequent simulations.

Table 5-1 illustrates the merits and problems of not having network simulation available in network management.

Network Simulation available	Lack of network simulation
Training on network behaviors Simulated network problem solving	Networks are learned at the expense of restoration time Training occurs on real problems or experienced personnel handle problems at the expense of training
Critical node analysis	Designed network nodes remain static with little chance of improvement
Traffic rerouting analysis	Traffic studies over long periods of time may be necessary to detect problem areas
Network dynamics fed into models	Models non-existent or based on perceived behaviors
Analytic tools built in	Precludes tedious manual manipulation of compiled traffic studies

Table 5-1 Network Simulation Aspects

2. Solution: Integrated Network Simulation

The integration of a Network simulation and modeling system into the SCAMPI SRC would allow the benefits detailed in Table 5-1. An additional use of simulation in network management has been the development of SNMP and protocol simulators. These devices, (hardware required), simulate any network device and function or malfunction. This can be very useful to the training of network management personnel and to test proactive measures implemented in a network. A predictable, repeatable network fault can be extremely useful.

H. SUMMARY OF RECOMMENDATIONS

Table 5-2 starts the summary of the recommendations for the USSOCOM SCAMPI

USSOCOM NMS					
Solution	**Hardware Factors**	**Software Factors**	**Personnel Factors**	**Cost Factors**	**Future Factors**
Distributed Management Presence	Primarily existing hardware	Required. Agents run on designated servers	Training on distributed management functionality	Per unit cost of agent in each Server location	Industry trends favor distributed management
WAN Level RMON Probe Functionality (SNMP /RMON limitations)	WAN Probes	Required for Interfacing to existing NMS	Training on WAN probe functionality and procedures	Cost per unit can be leveraged as utilized	RMON probes increasingly utilized on DoD networks
Application, and Protocol, Traffic Analysis Capability	LAN / WAN Probes	Required for NMS - Application Protocol monitoring	Adds requirements of traffic analysis	Can be incrementally adopted and proven.	Highly used by industry DoD is starting to use increasingly
Pro-active Mode of NMS	None envisioned	Requires software for function-ality	Automated restoration and proactive modes of operation	Cost of failure is high	Pro-active ability is required
Windows NT Server Monitoring Capacity	No new user hardware. Possibly NT server in SRC	Required for NMS - NT monitoring	Adds NT SMS and server functions to SRC tasking	Most functionality is resident in NT systems	NT OS is increasingly the DoD Standard
Network Simulation Ability	Some systems, (SNMP) require hardware	Required	Adds requirement of simulation utilization	Unknown factors discernible by simulation is desirable	Industry / DoD trends favor adoption

Table 5-2 Recommendation Summary Table

network. Table 5-2 gives a cross reference of each recommendation with the perceived hardware, software, personnel training and adjustment, cost and future factors for each area.

The format of the following tables is modeled after the industry survey tables in Chapter III to allow constant form and to enable cross comparison when considering vendor specific proposals.

The solutions and factors are non-vendor specific and therefore cost factors are particularly generic. Costs of probes and hardware are much akin to transportation. Basic transportation is one cost, high speed capability is usually extra. Unlike cars, network products and computers continue to decrease in cost per given capability. The T1 lines at USSOCOM, which used to represent high capacity in terms of network connectivity are easier to measure in terms of modern probes than the yet higher speed ATM capabilities on the near horizon.

Table 5-3 provides a cross reference between the NMS functional areas described in Chapter III and the recommended solutions. Some areas are blank. Not every recommendation solves a need in every functional area.

Recommended Solution vs NMS Functional Area	Performance Mgt.	Asset Config. Mgt.	Acct. Mgt.	Fault Mgt.	Security Mgt.
Distributed Management Presence	Higher poll rates of NMS objects with out affecting network performance	Multiple databases allows dual back ups	Auto-discovery in distributed role is more efficient	Better detection through enhanced presence	enhanced access point monitor functions
WAN Level RMON Probe Functionality (SNMP/RMON limitations)	Able to measure WAN metrics currently unavailable	- - -	- - -	Enabled WAN fault detection **(Not currently available)**	Ability to detect protocol, traffic related attacks
Application, and Protocol, Traffic Analysis Capability	Ability to measure critical parameters not now available	Ability to tune network to handle high BW loads	- - -	Issue alarms based on early detections	Ability to detect protocol, traffic attacks
Pro-active Mode of NMS	Faster resolution of performance bottlenecks	- - -	- - -	Fault restoration	- - -
Windows NT Server Monitoring Capacity	Able to add the NT SMS and server performance monitoring	Able to monitor NT assets, software, & configur-ations	Adds NT abilities for asset control and manage-ment	Increased area of fault detection	Enables NT security functions
Network Simulation	Increases ability to tune performance of network	Allows network design & planning	- - -	Improves network design and loadouts	- - -

Table 5-3 Recommendation vs NMS Functional Area

VI. NEAR TERM TECHNOLOGY IMPLICATIONS AND FUTURE RESEARCH

This chapter will address a selection of issues that can complicate the NMS decision maker's choices for implementation of solutions. It will also address technological changes and challenges. The indicators for industry trends in several key areas stand to radically change the way that networks work, and thus must be considered and managed. The chapter will also point out future research areas that could be carried on to improve the DoD's role in managing it's networks.

A. BANDWIDTH CRUNCH AND QOS ISSUES

Emerging applications, such as multimedia and full motion video will consume increasing amounts of bandwidth compared to text and still graphics. The experience of USSOCOM in implementing VTC on the SCAMPI network illustrates the potential for large bandwidth requirements. When the applications found at each individual desktop requires multimedia for training, or other job functions the network will face increasing demands on its resources.

The key issue that future technology brings is not just bandwidth but predictability of the service received. As an example, VTC and interactive video are less tolerant than older voice channels to the variances and latency found in conventional router based networks. The guaranteed QoS necessary to implement this application has been available thus far due to bandwidth allocations that do not switch. See Appendix A page 85 for an example of a circuit where bandwidth allocation was fixed for VTC utilization and was unable to be easily preempted. In a connection-oriented environment this luxury of dedicated circuits free from any potential collisions and competition may not be present. The next section on ATM

addresses such an environment.

B. ASYNCHRONOUS TRANSFER MODE (ATM) IMPLEMENTATION

USSOCOM as well as many other DoD users have plans for the near term addition of ATM circuits and connection to external ATM networks [Ref. 6]. ATM's connection-oriented nature demands a different type of network management and metrics determination. The implementation of ATM with its own unique metrics requires new tools. The decision will have to be made on the implementation of ATM Network management systems and metric gathering methodologies.

ATM is the cell-based multiplexing technology specified by the ITU-T and Committee T1 for use in integrating data, voice and video communications in Broadband Integrated Services Digital Networks (B-ISDNs) and emerging national and global information infrastructures. ATM uses cell-multiplexing and switching technology using fixed length packets. This network access protocol can operate over fiber-optic circuits with data rates of 1.5, 45, 100 and 150 Megabits per second (Mbps). [Ref. 29] The changes in NMS for ATM require the decision maker to either modify, add to, or replace the existing NMS to accommodate ATM.

Primary differences in the way information is handled in ATM illustrates the requirement that the SRC have a NMS that is powerful enough to accomplish the task. The information in ATM that requires monitoring includes: cell transfer delay, cell delay variation, errored cells, lost cells and misinserted cells. Impairments that would need monitoring include: individual bit errors, error bursts, and loss of frame events. Current monitoring methodology at USSOCOM and most DoD networks does not have the inherent ability to detect

these malfunctions. In addition the filter and capture speeds required of high speed ATM traffic creates the necessity to have dedicated monitoring devices that can monitor and buffer at least a million cells. The changing nature of the standards and specifications of ATM requires a flexible and upgradable analyzer that can stay current.

While being different in the transmission methodology, the functions that NMS has to perform on the circuits will remain very similar. The important consideration in implementing a NMS solution will be the ability to preserve training and fluency in the SRC with the new implementation. Functionality and processes that could share the existing NMS system and screens would minimize costs. If it is possible to implement an ATM monitoring and management system on the existing hardware without significant modification, the cost and learning curve time would both be significantly reduced.

C. SCALABILITY ISSUES

1. IP Next Version/Version 6 (IPV6)

The equipments used in most modern networks are based on the IPV4 and will have to consider the ramifications of the new IPV6 standard. IPV6 will provide support for (1) expanded addressing and routing capabilities, (2) a simplified header format, (3) extension headers and options, (4) authentication and privacy, (5) autoconfiguration, (6) simple and flexible transition to IPV6, and (7) increased quality of service capabilities. [Ref. 29]

Most of the new systems architectures proposed for the near term including, Defense Message System (DMS) and the Global Broadcast System (GBS) [or Defense Broadcast System (DBS)] , include the IPV6's anycast address scheme as an essential part. The ability to have vastly improved routing and addressing coupled with multicast capabilities will soon pressure

all networks to upgrade to the standard.

2. Year 2000 Compliance

All applications, solutions and devices that might be added need to be Year 2000 compliant to avoid obsolescence and possible network related failures. This will apply to the existing SCAMPI network NMS as well as any improvements. All operating systems, databases and even the Basic Input Output System (BIOS) on PC's will need to be compliant. Institutions have conducted testing of this potentially disabling phenomena by testing sections of their networks with an artificial setting ahead of all system clocks to 1/1/2000.

D. WEB BROWSER BASED TECHNOLOGY AND MANAGEMENT

1. Web Technology

The advent of the World Wide Web (WWW) and its related standards, has created a client server information system on the Internet (or any compliant network) that uses HyperText and multimedia techniques. This has enabled a consistent and simple means of accessing a variety of media. The HyperText Transfer Protocol (HTTP) is a protocol used for search and retrieval.

Most of the functionality of network based communications can be accomplished via this web browser technology. The management of network objects is possible within this mode. An early user of Web browsers to interface and demonstrate network management was the Stanford Linear Accelerator Center (SLAC). This concept is still being demonstrated online. Appendix D provides the connection information under the University section of http addresses.

2. Web Management - Industry Consortiums

Several companies have announced plans to pursue this mode of network management

through web browser technology.[Ref. 24] One such effort has been labeled Web-Based Enterprise Management (WBEM). WBEM is a collection of technologies that is designed to facilitate management of the enterprise network. These technologies were developed by a group of companies and are intended to work independent of vendor, protocol, or management standard. Typically, enterprise management has been tied to different protocols for different disciplines; for example, SNMP for network management. [Ref. 28]

Adopting elements of Object Oriented design, WBEM assumes that management problems are task-oriented and require tools that work together to provide a single management methodology. These standards are strongly influenced by advances in Internet technology, which has allowed for a new perspective on management.

WBEM does not attempt to replace existing management standards such as SNMP. In fact WBEM complements this standard by providing an integration point through which data from all network sources can be accessed. This makes any management applications independent of specific Application Program Interface (APIs) or standards used to instrument each managed entity, allowing correlation of data and events from multiple sources on a local or enterprise basis. A web-based demonstration of WBEM is available in either Active-X or JAVA on the web [Ref 28].

3. Decentralized NMS Functionality

The ability to decentralize NMS functionality will allow different approaches to network management. For example, a forward deployed SCAMPI node could conceptually be able to use browser technology to do equipment, line and performance checkouts. The future connectivity requirements of deployed troops may not follow classical military network lines

but may instead rely on more commercial connectivity that may not have direct dedicated oversight by a NOC such as the SRC. The ability to analyze performance and network operation at every level by users may become increasingly necessary as topologies mix and switch in the information grid.

E. JAVA DESIGN CONSIDERATIONS

Building on the rise of web browser technologies, the JAVA language, and its associated Management API base is well positioned to assume a dominant role in the future of network management and measurement. The ability to be platform independent and to write applications that are executable at all levels of technological ability within network devices, gives the NMS system of the near future tools and access that were heretofore impossible [Ref. 22].

The creation of browser based interfaces that allow the user to view and manipulate the attributes of his network have existed since late 1995. The commercial application and development of JAVA and web technology is continuing at a rapid pace. As most of the network interface is “built in” to the JAVA language the creation of network applications is now much easier and requires exponentially fewer lines of code.

The ability to write code once and have it be executable on any platform, UNIX workstation, PC, Macintosh, or any network device regardless of vendor will allow for simplification of network management and metrics collection. The requirements to have “plug-ins” to handle specific vendors product configuration and management functionality will no longer exist. What may result from this generic application may be the lack of human interface to the physical hardware. Current “plug-ins” create a artist rendition of the network hardware

that closely emulates the physical characteristics of the device.

Table 6-1 illustrates the features of each of the JAVA Management API components. [Ref. 22]. The features listed are the ones most relevant to the problems and solutions proposed in the thesis. The Management API set allows the creation of viewer interactive management tools. The set includes the ability to easily create user interfaces, gauges, and other human-computer interfaces.

JAVA Management API Component	Features, details:
Admin View Module (AWM)	An extension of the Abstract Window Toolkit (AWT). Used to build graphical tables, charts, and meters for visualization.
Base object interfaces	Defines core object types for distributed resources and services in a management system.
Managed container interfaces	Allows grouping of managed objects for better organization. Allows group-oriented approaches for complex systems.
Managed notification interfaces	Core foundation of managed event notification services. Can be expanded by developers to include system specific devices.
Managed data interfaces	Allows linking of managed object attributes to relational databases. Allows a transparent link between management resources and external databases.
Managed protocol interfaces	Uses the JAVA Security APIs and JAVA RMI to add distributed object support to the core functionality.
SNMP interfaces	Allows support for legacy SNMP agents. Allows interfacing with all compliant devices.
Applet integration interfaces	Allows applet integration to accomplish management functionality

Table 6-1 JAVA Management API Functionality

F. OBJECT ORIENTED MANAGEMENT CONSIDERATIONS

The requirement for reuse and cost savings on software design has prompted the DoD to examine the Object Oriented (OO) aspect of software, as in Ada, as well as other areas such as design and manufacturing processes. The JAVA language was built from its inception as an object oriented language. Using JAVA as an example the concepts of oriented design and network management will be discussed. The following paragraph is a representation of how network objects under a OO framework are classified, ordered and stored.

Each component in the management environment is referred to as a managed object, whose properties, attributes, and other information are stored in classes. These classes are organized into association and inheritance hierarchies, which are grouped by areas of interest, such as networking, applications, and systems. Each area of interest represents a schema, which is a subset of the information available about the management environment.

The primary goal and inherent gain in OO design and languages is the ability to handle similar network objects with a single software mechanism, regardless of the actual underlying hardware. The ability to create definitions, classes, and functions that are truly transparent to the network objects that are being managed will represent a true advancement of the art.

G. FUTURE DATA COLLECTION/ANALYSIS ACTIVITIES

Future data collection and analysis activities will evolve beyond the realms of packet switching infrastructure, towards optimizing service quality by such mechanisms as information caching and multicast. These activities and the incumbent management and analysis activities will increasingly require visualization based monitoring.

Graphical User interfaces (GUI's) changed the look and utilization of most computing

tasks. Visualization will bring conceptual understanding to processes that cannot be viewed or touched physically by the system operator. Visualization is important in making sense of complex problems and is especially critical for developing and maintaining the efficiency of logically overlaying architectures, such as caching, multicast, and IPV6 tunnel infrastructures. It will be increasingly important as systems change into dynamically shared and allocated network structures. Systems that do not make use of, or are not capable of, visualization will become increasingly labor intensive and less productive and proactive with time.

H. FUTURE RESEARCH

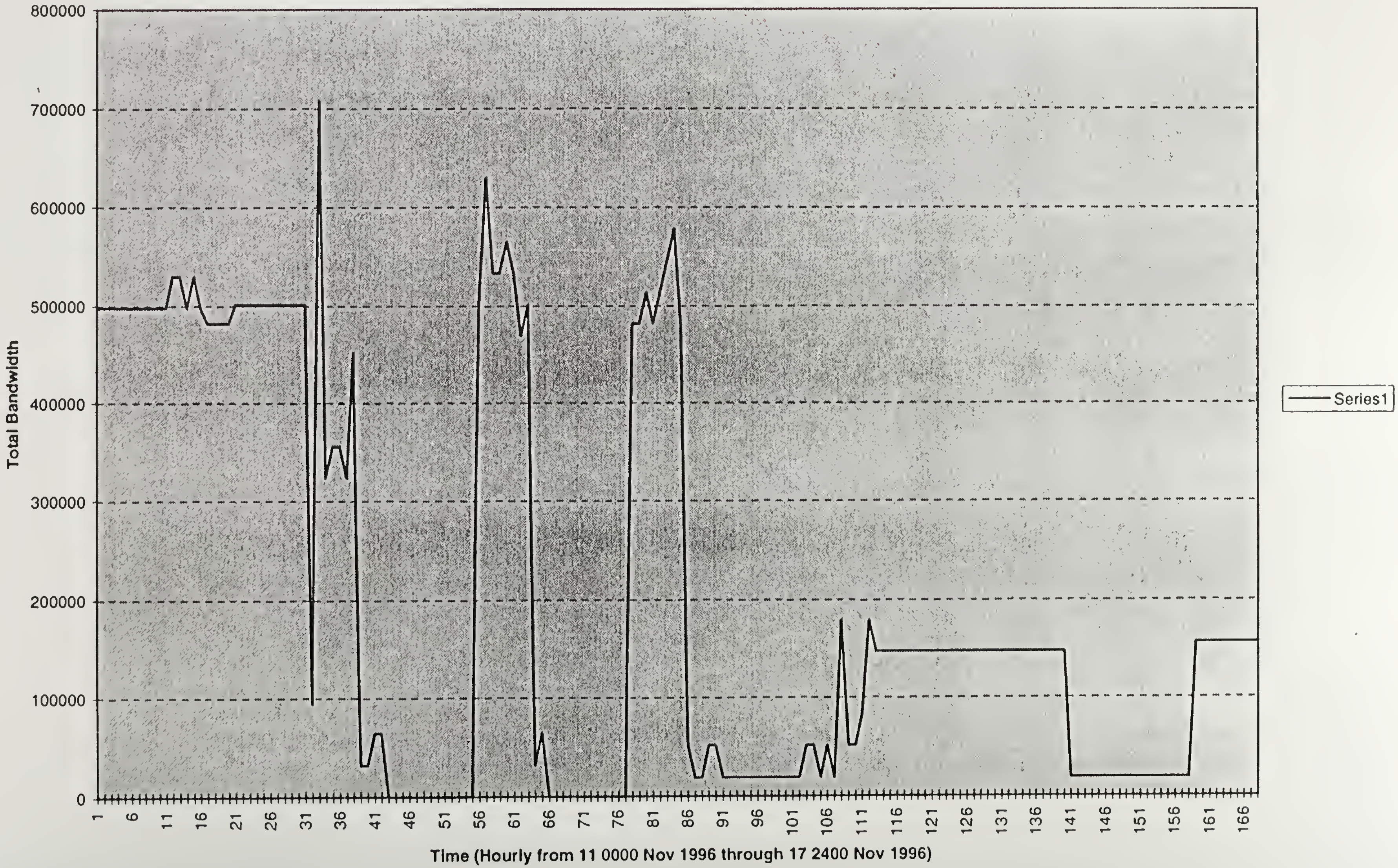
This thesis lays the ground work for follow-on activity either at USSOCOM or any other DoD organization needing network management/metrics research. It is hoped this initial work will be followed up in any of the network management/ metrics issue areas or future network application environments.

APPENDIX A. USSOCOM TRAFFIC STUDIES

This appendix consists of traffic studies collected from USSOCOM.

N6C20 Chart 1

MacDill AFB to Pentagon - 1024K



		MacDill AFB to Pentagon						
		1024K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/11/96	0:00:09	0	497943	497943	19	48.6%	19.7%	210280.2
11/11/96	1:00:09	0	497943	497943	19	48.6%		
11/11/96	2:00:09	0	497943	497943	19	48.6%		
11/11/96	3:00:09	0	497943	497943	19	48.6%	Average	Median
11/11/96	4:00:09	0	497943	497943	19	48.6%	202005	147200
11/11/96	5:00:09	0	497943	497943	19	48.6%		
11/11/96	6:00:09	0	497943	497943	19	48.6%		
11/11/96	7:00:09	0	497943	497943	19	48.6%		
11/11/96	8:00:09	0	497943	497943	19	48.6%		
11/11/96	9:00:08	0	497943	497943	19	48.6%		
11/11/96	10:00:09	0	497943	497943	19	48.6%		
11/11/96	11:00:10	32000	497943	529943	20	51.8%		
11/11/96	12:00:09	32000	497943	529943	20	51.8%		
11/11/96	13:00:09	0	497943	497943	19	48.6%		
11/11/96	14:00:09	32000	497943	529943	20	51.8%		
11/11/96	15:00:09	0	497943	497943	19	48.6%		
11/11/96	16:00:09	0	481943	481943	18	47.1%		
11/11/96	17:00:09	0	481943	481943	18	47.1%		
11/11/96	18:00:09	0	481943	481943	18	47.1%		
11/11/96	19:00:09	0	481943	481943	18	47.1%		
11/11/96	20:00:08	0	501143	501143	19	48.9%		
11/11/96	21:00:09	0	501143	501143	19	48.9%		
11/11/96	22:00:09	0	501143	501143	19	48.9%		
11/11/96	23:00:09	0	501143	501143	19	48.9%		
11/12/96	0:00:09	0	501143	501143	19	48.9%		
11/12/96	1:00:09	0	501143	501143	19	48.9%		
11/12/96	2:00:09	0	501143	501143	19	48.9%		
11/12/96	3:00:09	0	501143	501143	19	48.9%		
11/12/96	4:00:08	0	501143	501143	19	48.9%		
11/12/96	5:00:09	0	501143	501143	19	48.9%		
11/12/96	6:00:10	0	501143	501143	19	48.9%		
11/12/96	7:00:09	0	94400	94400	3	9.2%		
11/12/96	8:00:09	0	707543	707543	15	69.1%		
11/12/96	9:00:42	0	323543	323543	14	31.6%		
11/12/96	10:00:09	32000	323543	355543	15	34.7%		
11/12/96	11:00:09	32000	323543	355543	15	34.7%		
11/12/96	12:00:10	0	323543	323543	14	31.6%		
11/12/96	13:00:09	64000	387543	451543	17	44.1%		
11/12/96	14:00:12	32000	0	32000	1	3.1%		
11/12/96	15:00:09	32000	0	32000	1	3.1%		
11/12/96	16:00:09	64000	0	64000	2	6.3%		
11/12/96	17:00:09	64000	0	64000	2	6.3%		
11/12/96	18:00:09	0	0	0	0	0.0%		
11/12/96	19:00:09	0	0	0	0	0.0%		
11/12/96	20:00:10	0	0	0	0	0.0%		
11/12/96	21:00:08	0	0	0	0	0.0%		
11/12/96	22:00:09	0	0	0	0	0.0%		

Bandwidth Utilization Report
N6C20

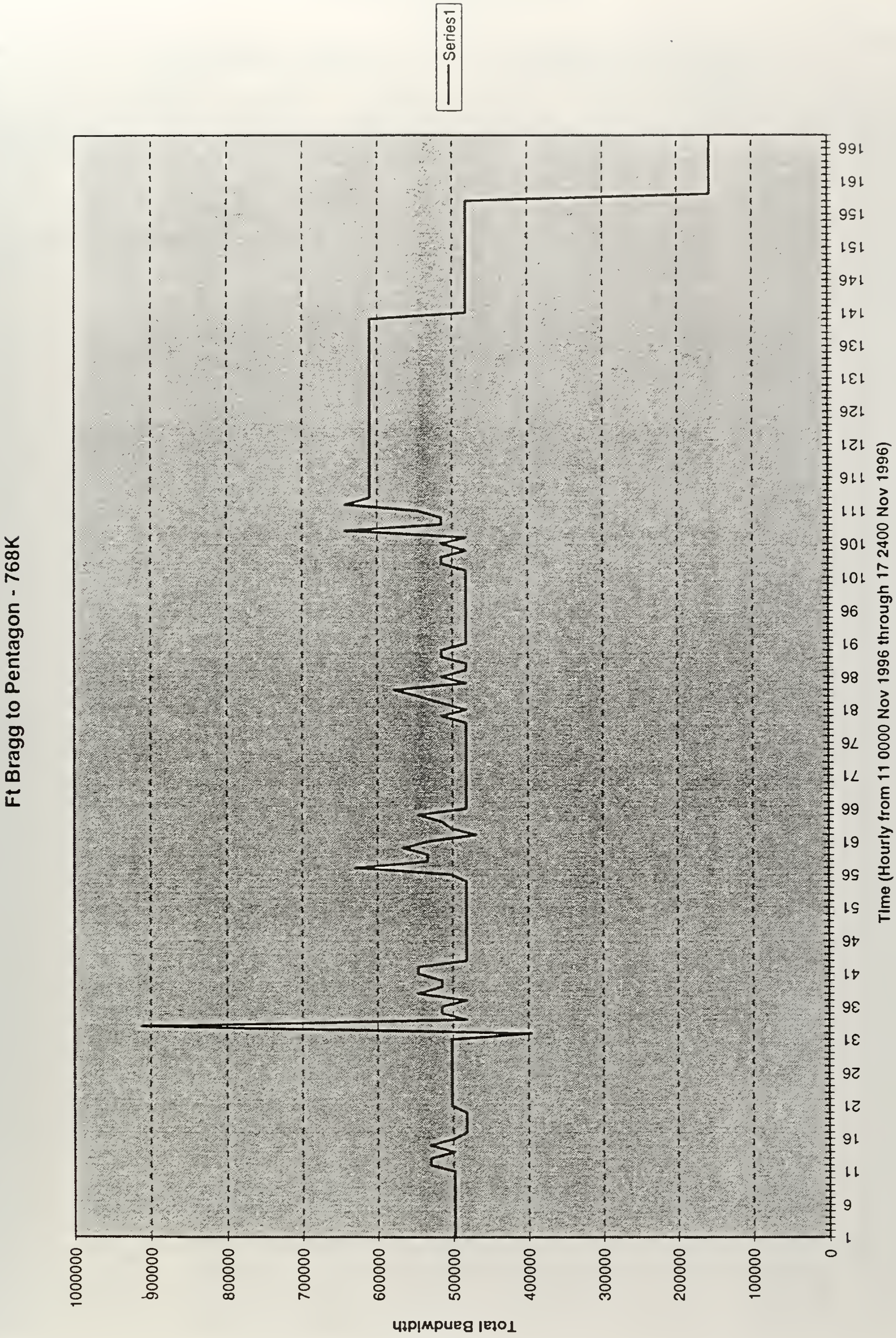
		MacDill AFB to Pentagon						
		1024K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/12/96	23:00:11	0	0	0	0	0.0%		
11/13/96	0:00:09	0	0	0	0	0.0%		
11/13/96	1:00:09	0	0	0	0	0.0%		
11/13/96	2:00:09	0	0	0	0	0.0%		
11/13/96	3:00:09	0	0	0	0	0.0%		
11/13/96	4:00:09	0	0	0	0	0.0%		
11/13/96	5:00:10	0	0	0	0	0.0%		
11/13/96	6:00:09	0	0	0	0	0.0%		
11/13/96	7:00:09	0	501143	501143	19	48.9%		
11/13/96	8:00:10	128000	501143	629143	23	61.4%		
11/13/96	9:00:08	32000	501143	533143	20	52.1%		
11/13/96	10:00:09	32000	501143	533143	20	52.1%		
11/13/96	11:00:09	64000	501143	565143	21	55.2%		
11/13/96	12:00:09	32000	501143	533143	20	52.1%		
11/13/96	13:00:10	32000	437143	469143	19	45.8%		
11/13/96	14:00:09	0	501143	501143	19	48.9%		
11/13/96	15:00:09	32000	0	32000	1	3.1%		
11/13/96	16:00:09	64000	0	64000	2	6.3%		
11/13/96	17:00:09	0	0	0	0	0.0%		
11/13/96	18:00:09	0	0	0	0	0.0%		
11/13/96	19:00:09	0	0	0	0	0.0%		
11/13/96	20:00:09	0	0	0	0	0.0%		
11/13/96	21:00:09	0	0	0	0	0.0%		
11/13/96	22:00:09	0	0	0	0	0.0%		
11/13/96	23:00:09	0	0	0	0	0.0%		
11/14/96	0:00:09	0	0	0	0	0.0%		
11/14/96	1:00:09	0	0	0	0	0.0%		
11/14/96	2:00:09	0	0	0	0	0.0%		
11/14/96	3:00:09	0	0	0	0	0.0%		
11/14/96	4:00:10	0	0	0	0	0.0%		
11/14/96	5:00:12	0	481943	481943	18	47.1%		
11/14/96	6:00:09	0	481943	481943	18	47.1%		
11/14/96	7:00:08	32000	481943	513943	19	50.2%		
11/14/96	8:00:09	0	481943	481943	18	47.1%		
11/14/96	9:09:30	32000	481943	513943	19	50.2%		
11/14/96	10:00:09	64000	481943	545943	20	53.3%		
11/14/96	11:00:09	96000	481943	577943	21	56.4%		
11/14/96	12:00:09	0	481943	481943	18	47.1%		
11/14/96	13:00:09	32000	19200	51200	2	5.0%		
11/14/96	14:00:09	0	19200	19200	1	1.9%		
11/14/96	15:00:09	0	19200	19200	1	1.9%		
11/14/96	16:00:10	32000	19200	51200	2	5.0%		
11/14/96	17:00:10	32000	19200	51200	2	5.0%		
11/14/96	18:00:09	0	19200	19200	1	1.9%		
11/14/96	19:00:08	0	19200	19200	1	1.9%		
11/14/96	20:00:08	0	19200	19200	1	1.9%		
11/14/96	21:00:10	0	19200	19200	1	1.9%		

Bandwidth Utilization Report
N6C20

		MacDill AFB to Pentagon						
		1024K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/14/96	22:00:09	0	19200	19200	1	1.9%		
11/14/96	23:00:10	0	19200	19200	1	1.9%		
11/15/96	0:00:09	0	19200	19200	1	1.9%		
11/15/96	1:00:09	0	19200	19200	1	1.9%		
11/15/96	2:00:09	0	19200	19200	1	1.9%		
11/15/96	3:00:10	0	19200	19200	1	1.9%		
11/15/96	4:00:11	0	19200	19200	1	1.9%		
11/15/96	5:00:09	0	19200	19200	1	1.9%		
11/15/96	6:00:41	32000	19200	51200	2	5.0%		
11/15/96	7:00:10	32000	19200	51200	2	5.0%		
11/15/96	8:00:10	0	19200	19200	1	1.9%		
11/15/96	9:00:09	32000	19200	51200	2	5.0%		
11/15/96	10:00:09	0	19200	19200	1	1.9%		
11/15/96	11:00:09	160000	19200	179200	6	17.5%		
11/15/96	12:00:10	32000	19200	51200	2	5.0%		
11/15/96	13:00:09	32000	19200	51200	2	5.0%		
11/15/96	14:00:08	64000	19200	83200	3	8.1%		
11/15/96	15:00:09	160000	19200	179200	6	17.5%		
11/15/96	16:00:09	128000	19200	147200	5	14.4%		
11/15/96	17:00:10	128000	19200	147200	5	14.4%		
11/15/96	18:00:09	128000	19200	147200	5	14.4%		
11/15/96	19:00:09	128000	19200	147200	5	14.4%		
11/15/96	20:00:09	128000	19200	147200	5	14.4%		
11/15/96	21:00:09	128000	19200	147200	5	14.4%		
11/15/96	22:00:09	128000	19200	147200	5	14.4%		
11/15/96	23:00:09	128000	19200	147200	5	14.4%		
11/15/96	0:00:09	128000	19200	147200	5	14.4%		
11/16/96	1:00:09	128000	19200	147200	5	14.4%		
11/16/96	2:00:09	128000	19200	147200	5	14.4%		
11/16/96	3:00:10	128000	19200	147200	5	14.4%		
11/16/96	4:00:09	128000	19200	147200	5	14.4%		
11/16/96	5:00:09	128000	19200	147200	5	14.4%		
11/16/96	6:00:09	128000	19200	147200	5	14.4%		
11/16/96	7:00:09	128000	19200	147200	5	14.4%		
11/16/96	8:00:09	128000	19200	147200	5	14.4%		
11/16/96	9:00:09	128000	19200	147200	5	14.4%		
11/16/96	10:00:09	128000	19200	147200	5	14.4%		
11/16/96	11:00:08	128000	19200	147200	5	14.4%		
11/16/96	12:00:10	128000	19200	147200	5	14.4%		
11/16/96	13:00:09	128000	19200	147200	5	14.4%		
11/16/96	14:00:09	128000	19200	147200	5	14.4%		
11/16/96	15:00:09	128000	19200	147200	5	14.4%		
11/16/96	16:00:09	128000	19200	147200	5	14.4%		
11/16/96	17:00:09	128000	19200	147200	5	14.4%		
11/16/96	18:00:09	128000	19200	147200	5	14.4%		
11/16/96	19:00:09	128000	19200	147200	5	14.4%		
11/16/96	20:00:09	0	19200	19200	1	1.9%		

Bandwidth Utilization Report
N6C20

		MacDill AFB to Pentagon						
		1024K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/16/96	21:00:09	0	19200	19200	1	1.9%		
11/16/96	22:00:26	0	19200	19200	1	1.9%		
11/16/96	23:00:09	0	19200	19200	1	1.9%		
11/17/96	0:00:09	0	19200	19200	1	1.9%		
11/17/96	1:00:09	0	19200	19200	1	1.9%		
11/17/96	2:00:09	0	19200	19200	1	1.9%		
11/17/96	3:00:09	0	19200	19200	1	1.9%		
11/17/96	4:00:10	0	19200	19200	1	1.9%		
11/17/96	5:00:09	0	19200	19200	1	1.9%		
11/17/96	6:00:09	0	19200	19200	1	1.9%		
11/17/96	7:00:09	0	19200	19200	1	1.9%		
11/17/96	8:00:09	0	19200	19200	1	1.9%		
11/17/96	9:00:09	0	19200	19200	1	1.9%		
11/17/96	10:00:09	0	19200	19200	1	1.9%		
11/17/96	11:00:08	0	19200	19200	1	1.9%		
11/17/96	12:00:09	0	19200	19200	1	1.9%		
11/17/96	13:00:11	0	19200	19200	1	1.9%		
11/17/96	14:00:09	0	156343	156343	7	15.3%		
11/17/96	15:00:09	0	156343	156343	7	15.3%		
11/17/96	16:00:17	0	156343	156343	7	15.3%		
11/17/96	17:00:09	0	156343	156343	7	15.3%		
11/17/96	18:00:09	0	156343	156343	7	15.3%		
11/17/96	19:00:08	0	156343	156343	7	15.3%		
11/17/96	20:00:09	0	156343	156343	7	15.3%		
11/17/96	21:00:09	0	156343	156343	7	15.3%		
11/17/96	22:00:09	0	156343	156343	7	15.3%		
11/17/96	23:00:09	0	156343	156343	7	15.3%		



Ft Bragg to Pentagon - 768K
Series1
Total Bandwidth
Time (Hourly from 11 0000 Nov 1996 through 17 2400 Nov 1996)

Bandwidth Utilization Report
N1N6

		Ft Bragg to Pentagon						
		768K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/11/96	0:00:06	0	497943	497943	19	64.8%	65.0%	103831.8
11/11/96	1:00:06	0	497943	497943	19	64.8%		
11/11/96	2:00:06	0	497943	497943	19	64.8%		
11/11/96	3:00:06	0	497943	497943	19	64.8%	Average	Median
11/11/96	4:00:06	0	497943	497943	19	64.8%	499348	497943
11/11/96	5:00:06	0	497943	497943	19	64.8%		
11/11/96	6:00:06	0	497943	497943	19	64.8%		
11/11/96	7:00:06	0	497943	497943	19	64.8%		
11/11/96	8:00:07	0	497943	497943	19	64.8%		
11/11/96	9:00:05	0	497943	497943	19	64.8%		
11/11/96	10:00:06	0	497943	497943	19	64.8%		
11/11/96	11:00:06	32000	497943	529943	20	69.0%		
11/11/96	12:00:06	32000	497943	529943	20	69.0%		
11/11/96	13:00:06	0	497943	497943	19	64.8%		
11/11/96	14:00:06	32000	497943	529943	20	69.0%		
11/11/96	15:00:06	0	497943	497943	19	64.8%		
11/11/96	16:00:06	0	481943	481943	18	62.8%		
11/11/96	17:00:06	0	481943	481943	18	62.8%		
11/11/96	18:00:06	0	481943	481943	18	62.8%		
11/11/96	19:00:06	0	481943	481943	18	62.8%		
11/11/96	20:00:06	0	501143	501143	19	65.3%		
11/11/96	21:00:06	0	501143	501143	19	65.3%		
11/11/96	22:00:07	0	501143	501143	19	65.3%		
11/11/96	23:00:07	0	501143	501143	19	65.3%		
11/12/96	0:00:06	0	501143	501143	19	65.3%		
11/12/96	1:00:06	0	501143	501143	19	65.3%		
11/12/96	2:00:06	0	501143	501143	19	65.3%		
11/12/96	3:00:06	0	501143	501143	19	65.3%		
11/12/96	4:00:06	0	501143	501143	19	65.3%		
11/12/96	5:00:06	0	501143	501143	19	65.3%		
11/12/96	6:00:07	0	501143	501143	19	65.3%		
11/12/96	7:00:07	0	396343	396343	19	51.6%		
11/12/96	8:00:06	64000	846743	910743	20	118.6%		
11/12/96	9:00:08	0	481943	481943	19	62.8%		
11/12/96	10:00:06	32000	481943	513943	19	66.9%		
11/12/96	11:00:06	32000	481943	513943	19	66.9%		
11/12/96	12:00:06	0	481943	481943	19	62.8%		
11/12/96	13:00:07	64000	481943	545943	20	71.1%		
11/12/96	14:00:09	32000	481943	513943	19	66.9%		
11/12/96	15:00:06	32000	481943	513943	19	66.9%		
11/12/96	16:00:06	64000	481943	545943	20	71.1%		
11/12/96	17:00:06	64000	481943	545943	20	71.1%		
11/12/96	18:00:06	0	481943	481943	18	62.8%		
11/12/96	19:00:06	0	481943	481943	18	62.8%		
11/12/96	20:00:06	0	481943	481943	18	62.8%		
11/12/96	21:00:06	0	481943	481943	18	62.8%		
11/12/96	22:00:06	0	481943	481943	18	62.8%		

		Ft Bragg to Pentagon						
		768K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/12/96	23:00:07	0	481943	481943	18	62.8%		
11/13/96	0:00:07	0	481943	481943	18	62.8%		
11/13/96	1:00:06	0	481943	481943	18	62.8%		
11/13/96	2:00:06	0	481943	481943	18	62.8%		
11/13/96	3:00:06	0	481943	481943	18	62.8%		
11/13/96	4:00:06	0	481943	481943	18	62.8%		
11/13/96	5:00:07	0	481943	481943	18	62.8%		
11/13/96	6:00:06	0	481943	481943	18	62.8%		
11/13/96	7:00:06	0	501143	501143	19	65.3%		
11/13/96	8:00:07	128000	501143	629143	23	81.9%		
11/13/96	9:00:06	32000	501143	533143	20	69.4%		
11/13/96	10:00:06	32000	501143	533143	20	69.4%		
11/13/96	11:00:06	64000	501143	565143	21	73.6%		
11/13/96	12:00:06	32000	501143	533143	20	69.4%		
11/13/96	13:00:07	32000	437143	469143	19	61.1%		
11/13/96	14:00:06	0	501143	501143	19	65.3%		
11/13/96	15:00:07	32000	481943	513943	19	66.9%		
11/13/96	16:00:06	64000	481943	545943	20	71.1%		
11/13/96	17:00:07	0	481943	481943	18	62.8%		
11/13/96	18:00:07	0	481943	481943	18	62.8%		
11/13/96	19:00:06	0	481943	481943	18	62.8%		
11/13/96	20:00:06	0	481943	481943	18	62.8%		
11/13/96	21:00:06	0	481943	481943	18	62.8%		
11/13/96	22:00:06	0	481943	481943	18	62.8%		
11/13/96	23:00:06	0	481943	481943	18	62.8%		
11/14/96	0:00:06	0	481943	481943	18	62.8%		
11/14/96	1:00:06	0	481943	481943	18	62.8%		
11/14/96	2:00:07	0	481943	481943	18	62.8%		
11/14/96	3:00:06	0	481943	481943	18	62.8%		
11/14/96	4:00:07	0	481943	481943	18	62.8%		
11/14/96	5:00:09	0	481943	481943	18	62.8%		
11/14/96	6:00:06	0	481943	481943	18	62.8%		
11/14/96	7:00:06	32000	481943	513943	18	66.9%		
11/14/96	8:00:06	0	481943	481943	18	62.8%		
11/14/96	9:09:28	32000	481943	513943	19	66.9%		
11/14/96	10:00:06	64000	481943	545943	20	71.1%		
11/14/96	11:00:06	96000	481943	577943	21	75.3%		
11/14/96	12:00:06	0	481943	481943	18	62.8%		
11/14/96	13:00:06	32000	481943	513943	19	66.9%		
11/14/96	14:00:06	0	481943	481943	18	62.8%		
11/14/96	15:00:06	0	481943	481943	18	62.8%		
11/14/96	16:00:07	32000	481943	513943	19	66.9%		
11/14/96	17:00:07	32000	481943	513943	19	66.9%		
11/14/96	18:00:06	0	481943	481943	18	62.8%		
11/14/96	19:00:06	0	481943	481943	18	62.8%		
11/14/96	20:00:06	0	481943	481943	18	62.8%		
11/14/96	21:01:15	0	481943	481943	18	62.8%		

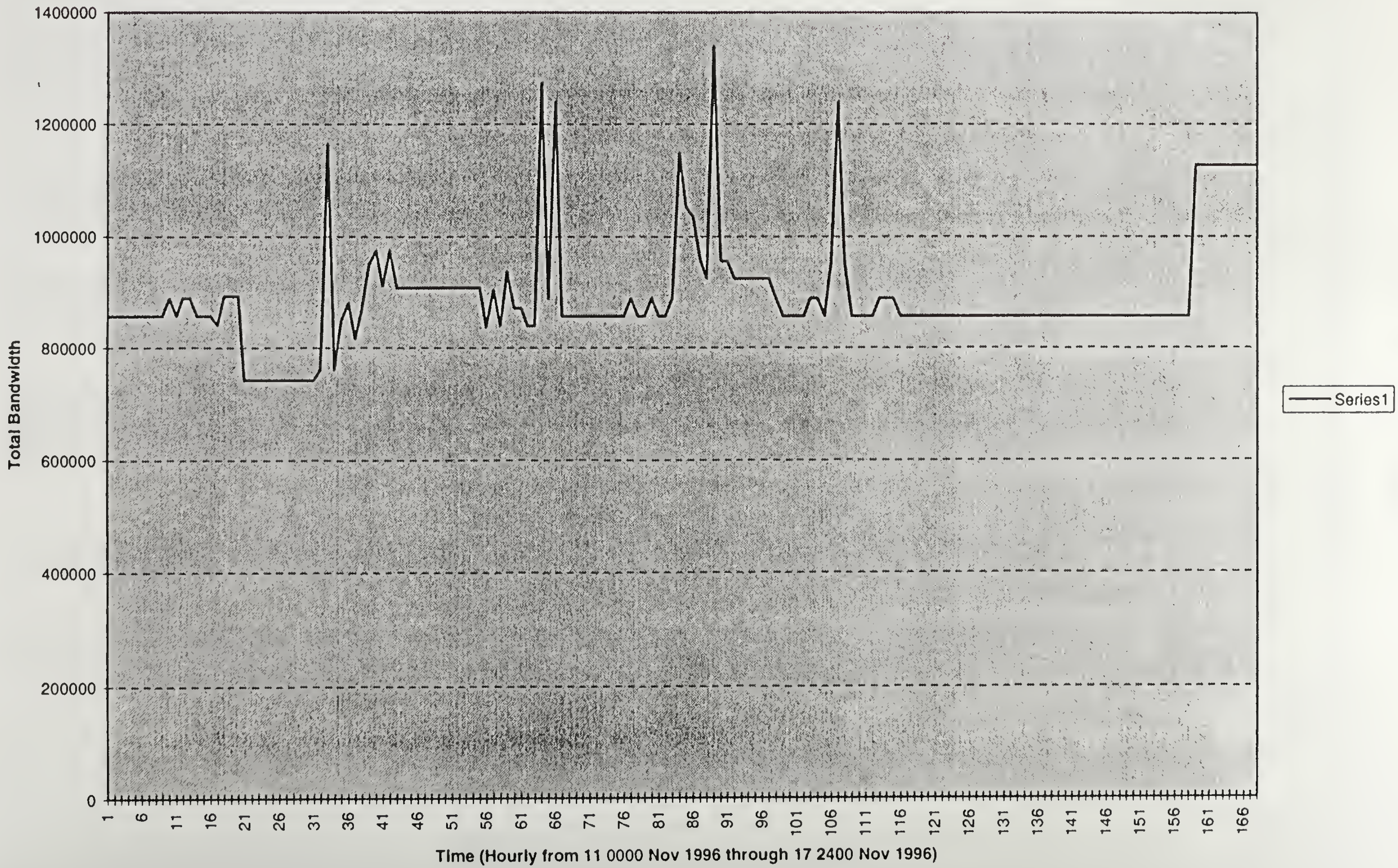
		Ft Bragg to Pentagon						
		768K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/14/96	22:00:06	0	481943	481943	18	62.8%		
11/14/96	23:00:07	0	481943	481943	18	62.8%		
11/15/96	0:00:06	0	481943	481943	18	62.8%		
11/15/96	1:00:06	0	481943	481943	18	62.8%		
11/15/96	2:00:06	0	481943	481943	18	62.8%		
11/15/96	3:00:06	0	481943	481943	18	62.8%		
11/15/96	4:00:08	0	481943	481943	18	62.8%		
11/15/96	5:00:06	0	481943	481943	18	62.8%		
11/15/96	6:00:39	32000	481943	513943	19	66.9%		
11/15/96	7:00:08	32000	481943	513943	19	66.9%		
11/15/96	8:00:07	0	481943	481943	18	62.8%		
11/15/96	9:00:06	32000	481943	513943	19	66.9%		
11/15/96	10:00:06	0	481943	481943	18	62.8%		
11/15/96	11:00:06	160000	481943	641943	23	83.6%		
11/15/96	12:00:07	32000	481943	513943	19	66.9%		
11/15/96	13:00:07	32000	481943	513943	19	66.9%		
11/15/96	14:00:06	64000	481943	545943	20	71.1%		
11/15/96	15:00:06	160000	481943	641943	23	83.6%		
11/15/96	16:00:06	128000	481943	609943	22	79.4%		
11/15/96	17:00:07	128000	481943	609943	22	79.4%		
11/15/96	18:00:06	128000	481943	609943	22	79.4%		
11/15/96	19:00:06	128000	481943	609943	22	79.4%		
11/15/96	20:00:07	128000	481943	609943	22	79.4%		
11/15/96	21:00:07	128000	481943	609943	22	79.4%		
11/15/96	22:00:06	128000	481943	609943	22	79.4%		
11/15/96	23:00:06	128000	481943	609943	22	79.4%		
11/16/96	0:00:06	128000	481943	609943	22	79.4%		
11/16/96	1:00:07	128000	481943	609943	22	79.4%		
11/16/96	2:00:06	128000	481943	609943	22	79.4%		
11/16/96	3:00:07	128000	481943	609943	22	79.4%		
11/16/96	4:00:06	128000	481943	609943	22	79.4%		
11/16/96	5:00:06	128000	481943	609943	22	79.4%		
11/16/96	6:00:07	128000	481943	609943	22	79.4%		
11/16/96	7:00:07	128000	481943	609943	22	79.4%		
11/16/96	8:00:07	128000	481943	609943	22	79.4%		
11/16/96	9:00:06	128000	481943	609943	22	79.4%		
11/16/96	10:00:06	128000	481943	609943	22	79.4%		
11/16/96	11:00:06	128000	481943	609943	22	79.4%		
11/16/96	12:00:06	128000	481943	609943	22	79.4%		
11/16/96	13:00:06	128000	481943	609943	22	79.4%		
11/16/96	14:00:06	128000	481943	609943	22	79.4%		
11/16/96	15:00:06	128000	481943	609943	22	79.4%		
11/16/96	16:00:06	128000	481943	609943	22	79.4%		
11/16/96	17:00:06	128000	481943	609943	22	79.4%		
11/16/96	18:00:06	128000	481943	609943	22	79.4%		
11/16/96	19:00:06	128000	481943	609943	22	79.4%		
11/16/96	20:00:06	0	481943	481943	18	62.8%		

Bandwidth Utilization Report
N1N6

		Ft Bragg to Pentagon						
		768K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/16/96	21:00:06	0	481943	481943	18	62.8%		
11/16/96	22:00:06	0	481943	481943	18	62.8%		
11/16/96	23:00:06	0	481943	481943	18	62.8%		
11/17/96	0:00:06	0	481943	481943	18	62.8%		
11/17/96	1:00:06	0	481943	481943	18	62.8%		
11/17/96	2:00:06	0	481943	481943	18	62.8%		
11/17/96	3:00:06	0	481943	481943	18	62.8%		
11/17/96	4:00:07	0	481943	481943	18	62.8%		
11/17/96	5:00:06	0	481943	481943	18	62.8%		
11/17/96	6:00:06	0	481943	481943	18	62.8%		
11/17/96	7:00:06	0	481943	481943	18	62.8%		
11/17/96	8:00:06	0	481943	481943	18	62.8%		
11/17/96	9:00:06	0	481943	481943	18	62.8%		
11/17/96	10:00:06	0	481943	481943	18	62.8%		
11/17/96	11:00:06	0	481943	481943	18	62.8%		
11/17/96	12:00:06	0	481943	481943	18	62.8%		
11/17/96	13:00:07	0	481943	481943	18	62.8%		
11/17/96	14:00:06	0	156343	156343	7	20.4%		
11/17/96	15:00:06	0	156343	156343	7	20.4%		
11/17/96	16:00:15	0	156343	156343	7	20.4%		
11/17/96	17:00:06	0	156343	156343	7	20.4%		
11/17/96	18:00:06	0	156343	156343	7	20.4%		
11/17/96	19:00:06	0	156343	156343	7	20.4%		
11/17/96	20:00:06	0	156343	156343	7	20.4%		
11/17/96	21:00:06	0	156343	156343	7	20.4%		
11/17/96	22:00:06	0	156343	156343	7	20.4%		
11/17/96	23:00:06	0	156343	156343	7	20.4%		

N1N4 Chart 1

Ft Bragg to MacDill AFB - 3@768K



		Ft Bragg to MacDill AFB						
		3@768K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/11/96	0:00:05	0	856800	856800	10	37.2%	38.9%	102877.5
11/11/96	1:00:05	0	856800	856800	10	37.2%		
11/11/96	2:00:06	0	856800	856800	10	37.2%		
11/11/96	3:00:06	0	856800	856800	10	37.2%	Average	Median
11/11/96	4:00:06	0	856800	856800	10	37.2%	895324	856800
11/11/96	5:00:06	0	856800	856800	10	37.2%		
11/11/96	6:00:06	0	856800	856800	10	37.2%		
11/11/96	7:00:06	0	856800	856800	10	37.2%		
11/11/96	8:00:06	0	856800	856800	10	37.2%		
11/11/96	9:00:05	32000	856800	888800	11	38.6%		
11/11/96	10:00:06	0	856800	856800	10	37.2%		
11/11/96	11:00:06	32000	856800	888800	11	38.6%		
11/11/96	12:00:06	32000	856800	888800	11	38.6%		
11/11/96	13:00:06	0	856800	856800	10	37.2%		
11/11/96	14:00:05	0	856800	856800	10	37.2%		
11/11/96	15:00:06	0	856800	856800	10	37.2%		
11/11/96	16:00:05	0	840800	840800	9	36.5%		
11/11/96	17:00:05	0	892000	892000	12	38.7%		
11/11/96	18:00:06	0	892000	892000	12	38.7%		
11/11/96	19:00:05	0	892000	892000	12	38.7%		
11/11/96	20:00:05	0	741600	741600	6	32.2%		
11/11/96	21:00:06	0	741600	741600	6	32.2%		
11/11/96	22:00:06	0	741600	741600	6	32.2%		
11/11/96	23:00:06	0	741600	741600	6	32.2%		
11/12/96	0:00:05	0	741600	741600	6	32.2%		
11/12/96	1:00:06	0	741600	741600	6	32.2%		
11/12/96	2:00:05	0	741600	741600	6	32.2%		
11/12/96	3:00:05	0	741600	741600	6	32.2%		
11/12/96	4:00:05	0	741600	741600	6	32.2%		
11/12/96	5:00:06	0	741600	741600	6	32.2%		
11/12/96	6:00:06	0	741600	741600	6	32.2%		
11/12/96	7:00:06	0	760800	760800	7	33.0%		
11/12/96	8:00:06	0	1164000	1164000	9	50.5%		
11/12/96	9:00:07	0	760800	760800	7	33.0%		
11/12/96	10:00:06	32000	816800	848800	9	36.8%		
11/12/96	11:00:06	64000	816800	880800	10	38.2%		
11/12/96	12:00:06	0	816800	816800	8	35.5%		
11/12/96	13:00:06	0	870400	870400	12	37.8%		
11/12/96	14:00:08	64000	886400	950400	15	41.3%		
11/12/96	15:00:05	64000	910400	974400	16	42.3%		
11/12/96	16:00:06	0	910400	910400	14	39.5%		
11/12/96	17:00:05	64000	910400	974400	16	42.3%		
11/12/96	18:00:05	0	908000	908000	13	39.4%		
11/12/96	19:00:05	0	908000	908000	13	39.4%		
11/12/96	20:00:06	0	908000	908000	13	39.4%		
11/12/96	21:00:05	0	908000	908000	13	39.4%		
11/12/96	22:00:06	0	908000	908000	13	39.4%		

Bandwidth Utilization Report
N1N4

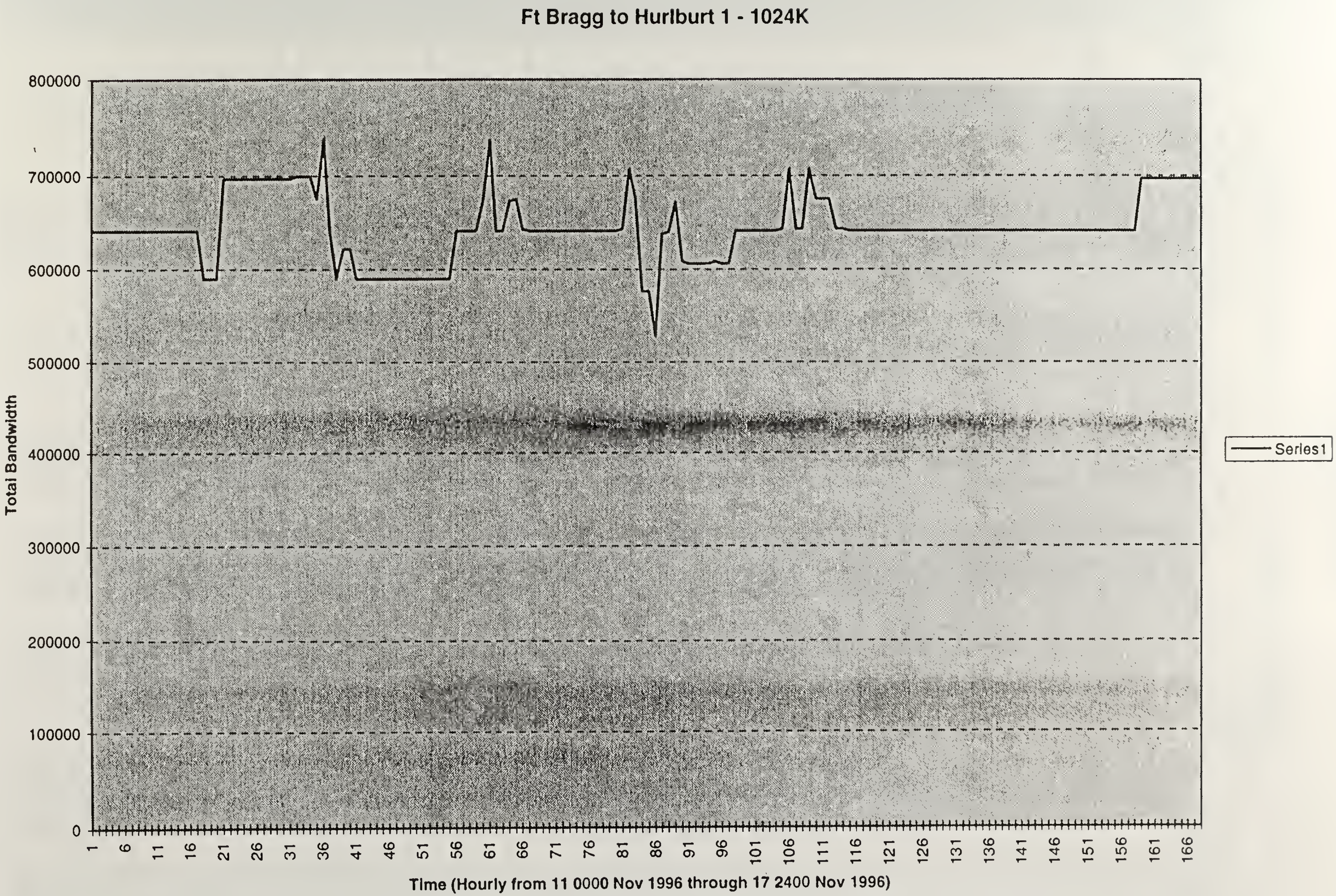
		Ft Bragg to MacDill AFB						
		3@768K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/12/96	23:00:06	0	908000	908000	13	39.4%		
11/13/96	0:00:06	0	908000	908000	13	39.4%		
11/13/96	1:00:05	0	908000	908000	13	39.4%		
11/13/96	2:00:06	0	908000	908000	13	39.4%		
11/13/96	3:00:06	0	908000	908000	13	39.4%		
11/13/96	4:00:05	0	908000	908000	13	39.4%		
11/13/96	5:00:06	0	908000	908000	13	39.4%		
11/13/96	6:00:06	0	908000	908000	13	39.4%		
11/13/96	7:00:05	0	837600	837600	9	36.4%		
11/13/96	8:00:06	64000	840000	904000	12	39.2%		
11/13/96	9:00:05	0	840000	840000	10	36.5%		
11/13/96	10:00:06	96000	840000	936000	13	40.6%		
11/13/96	11:00:05	32000	840000	872000	11	37.8%		
11/13/96	12:00:05	32000	840000	872000	11	37.8%		
11/13/96	13:00:06	0	840000	840000	10	36.5%		
11/13/96	14:00:05	0	840000	840000	10	36.5%		
11/13/96	15:00:06	416000	859200	1275200	18	55.3%		
11/13/96	16:00:05	32000	856800	888800	11	38.6%		
11/13/96	17:00:06	0	1240800	1240800	16	53.9%		
11/13/96	18:00:06	0	856800	856800	10	37.2%		
11/13/96	19:00:05	0	856800	856800	10	37.2%		
11/13/96	20:00:06	0	856800	856800	10	37.2%		
11/13/96	21:00:05	0	856800	856800	10	37.2%		
11/13/96	22:00:05	0	856800	856800	10	37.2%		
11/13/96	23:00:06	0	856800	856800	10	37.2%		
11/14/96	0:00:06	0	856800	856800	10	37.2%		
11/14/96	1:00:05	0	856800	856800	10	37.2%		
11/14/96	2:00:06	0	856800	856800	10	37.2%		
11/14/96	3:00:06	0	856800	856800	10	37.2%		
11/14/96	4:00:06	32000	856800	888800	11	38.6%		
11/14/96	5:00:07	0	856800	856800	10	37.2%		
11/14/96	6:00:05	0	856800	856800	10	37.2%		
11/14/96	7:00:05	32000	856800	888800	11	38.6%		
11/14/96	8:00:05	0	856800	856800	10	37.2%		
11/14/96	9:09:27	0	856800	856800	10	37.2%		
11/14/96	10:00:05	32000	856800	888800	11	38.6%		
11/14/96	11:00:06	160000	988000	1148000	22	49.8%		
11/14/96	12:00:05	64000	988000	1052000	19	45.7%		
11/14/96	13:00:05	64000	972000	1036000	18	45.0%		
11/14/96	14:00:06	64000	894400	958400	15	41.6%		
11/14/96	15:00:06	32000	892000	924000	13	40.1%		
11/14/96	16:00:07	448000	892000	1340000	20	58.2%		
11/14/96	17:00:06	64000	892000	956000	14	41.5%		
11/14/96	18:00:05	64000	892000	956000	14	41.5%		
11/14/96	19:00:05	32000	892000	924000	13	40.1%		
11/14/96	20:00:05	32000	892000	924000	13	40.1%		
11/14/96	21:00:05	32000	892000	924000	13	40.1%		

Bandwidth Utilization Report
N1N4

		Ft Bragg to MacDill AFB						
		3@768K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/14/96	22:00:06	32000	892000	924000	13	40.1%		
11/14/96	23:00:06	32000	892000	924000	13	40.1%		
11/15/96	0:00:05	32000	892000	924000	13	40.1%		
11/15/96	1:00:06	32000	856800	888800	11	38.6%		
11/15/96	2:00:05	0	856800	856800	10	37.2%		
11/15/96	3:00:05	0	856800	856800	10	37.2%		
11/15/96	4:00:05	0	856800	856800	10	37.2%		
11/15/96	5:00:06	0	856800	856800	10	37.2%		
11/15/96	6:00:38	32000	856800	888800	11	38.6%		
11/15/96	7:00:07	32000	856800	888800	11	38.6%		
11/15/96	8:00:06	0	856800	856800	10	37.2%		
11/15/96	9:00:05	96000	856800	952800	13	41.4%		
11/15/96	10:00:05	0	1240800	1240800	16	53.9%		
11/15/96	11:00:06	96000	856800	952800	13	41.4%		
11/15/96	12:00:06	0	856800	856800	10	37.2%		
11/15/96	13:00:06	0	856800	856800	10	37.2%		
11/15/96	14:00:05	0	856800	856800	10	37.2%		
11/15/96	15:00:05	0	856800	856800	10	37.2%		
11/15/96	16:00:05	32000	856800	888800	11	38.6%		
11/15/96	17:00:06	32000	856800	888800	11	38.6%		
11/15/96	18:00:05	32000	856800	888800	11	38.6%		
11/15/96	19:00:05	0	856800	856800	10	37.2%		
11/15/96	20:00:06	0	856800	856800	10	37.2%		
11/15/96	21:00:06	0	856800	856800	10	37.2%		
11/15/96	22:00:06	0	856800	856800	10	37.2%		
11/15/96	23:00:06	0	856800	856800	10	37.2%		
11/16/96	0:00:05	0	856800	856800	10	37.2%		
11/16/96	1:00:06	0	856800	856800	10	37.2%		
11/16/96	2:00:05	0	856800	856800	10	37.2%		
11/16/96	3:00:07	0	856800	856800	10	37.2%		
11/16/96	4:00:05	0	856800	856800	10	37.2%		
11/16/96	5:00:05	0	856800	856800	10	37.2%		
11/16/96	6:00:06	0	856800	856800	10	37.2%		
11/16/96	7:00:06	0	856800	856800	10	37.2%		
11/16/96	8:00:06	0	856800	856800	10	37.2%		
11/16/96	9:00:05	0	856800	856800	10	37.2%		
11/16/96	10:00:05	0	856800	856800	10	37.2%		
11/16/96	11:00:05	0	856800	856800	10	37.2%		
11/16/96	12:00:06	0	856800	856800	10	37.2%		
11/16/96	13:00:05	0	856800	856800	10	37.2%		
11/16/96	14:00:05	0	856800	856800	10	37.2%		
11/16/96	15:00:05	0	856800	856800	10	37.2%		
11/16/96	16:00:05	0	856800	856800	10	37.2%		
11/16/96	17:00:05	0	856800	856800	10	37.2%		
11/16/96	18:00:06	0	856800	856800	10	37.2%		
11/16/96	19:00:05	0	856800	856800	10	37.2%		
11/16/96	20:00:05	0	856800	856800	10	37.2%		

Bandwidth Utilization Report
N1N4

		Ft Bragg to MacDill AFB						
		3@768K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/16/96	21:00:06	0	856800	856800	10	37.2%		
11/16/96	22:00:05	0	856800	856800	10	37.2%		
11/16/96	23:00:06	0	856800	856800	10	37.2%		
11/17/96	0:00:05	0	856800	856800	10	37.2%		
11/17/96	1:00:05	0	856800	856800	10	37.2%		
11/17/96	2:00:05	0	856800	856800	10	37.2%		
11/17/96	3:00:06	0	856800	856800	10	37.2%		
11/17/96	4:00:06	0	856800	856800	10	37.2%		
11/17/96	5:00:05	0	856800	856800	10	37.2%		
11/17/96	6:00:05	0	856800	856800	10	37.2%		
11/17/96	7:00:06	0	856800	856800	10	37.2%		
11/17/96	8:00:06	0	856800	856800	10	37.2%		
11/17/96	9:00:05	0	856800	856800	10	37.2%		
11/17/96	10:00:05	0	856800	856800	10	37.2%		
11/17/96	11:00:05	0	856800	856800	10	37.2%		
11/17/96	12:00:05	0	856800	856800	10	37.2%		
11/17/96	13:00:05	0	856800	856800	10	37.2%		
11/17/96	14:00:05	0	1126400	1126400	20	48.9%		
11/17/96	15:00:06	0	1126400	1126400	20	48.9%		
11/17/96	16:00:14	0	1126400	1126400	20	48.9%		
11/17/96	17:00:05	0	1126400	1126400	20	48.9%		
11/17/96	18:00:05	0	1126400	1126400	20	48.9%		
11/17/96	19:00:05	0	1126400	1126400	20	48.9%		
11/17/96	20:00:06	0	1126400	1126400	20	48.9%		
11/17/96	21:00:05	0	1126400	1126400	20	48.9%		
11/17/96	22:00:05	0	1126400	1126400	20	48.9%		
11/17/96	23:00:05	0	1126400	1126400	20	48.9%		


Ft Bragg to Hurlburt 1 - 1024K
Total Bandwidth
800000
700000
600000
500000
400000
300000
200000
100000
0
1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96 101 106 111 116 121 126 131 136 141 146 151 156 161 166
Time (Hourly from 11 0000 Nov 1996 through 17 2400 Nov 1996)
Series1

Bandwidth Utilization Report
N1N9

		Ft Bragg to Hurlburt 1						
		1024K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/11/96	0:00:04	0	640800	640800	7	62.6%	62.9%	34328.07
11/11/96	1:00:04	0	640800	640800	7	62.6%		
11/11/96	2:00:05	0	640800	640800	7	62.6%		
11/11/96	3:00:05	0	640800	640800	7	62.6%	Average	Median
11/11/96	4:00:05	0	640800	640800	7	62.6%	643948	640800
11/11/96	5:00:05	0	640800	640800	7	62.6%		
11/11/96	6:00:05	0	640800	640800	7	62.6%		
11/11/96	7:00:05	0	640800	640800	7	62.6%		
11/11/96	8:00:05	0	640800	640800	7	62.6%		
11/11/96	9:00:04	0	640800	640800	7	62.6%		
11/11/96	10:00:05	0	640800	640800	7	62.6%		
11/11/96	11:00:05	0	640800	640800	7	62.6%		
11/11/96	12:00:05	0	640800	640800	7	62.6%		
11/11/96	13:00:05	0	640800	640800	7	62.6%		
11/11/96	14:00:05	0	640800	640800	7	62.6%		
11/11/96	15:00:05	0	640800	640800	7	62.6%		
11/11/96	16:00:04	0	640800	640800	7	62.6%		
11/11/96	17:00:04	0	589600	589600	4	57.6%		
11/11/96	18:00:05	0	589600	589600	8	57.6%		
11/11/96	19:00:04	0	589600	589600	8	57.6%		
11/11/96	20:00:04	0	696800	696800	8	68.0%		
11/11/96	21:00:05	0	696800	696800	8	68.0%		
11/11/96	22:00:05	0	696800	696800	8	68.0%		
11/11/96	23:00:05	0	696800	696800	8	68.0%		
11/12/96	0:00:05	0	696800	696800	8	68.0%		
11/12/96	1:00:04	0	696800	696800	8	68.0%		
11/12/96	2:00:05	0	696800	696800	8	68.0%		
11/12/96	3:00:05	0	696800	696800	8	68.0%		
11/12/96	4:00:04	0	696800	696800	8	68.0%		
11/12/96	5:00:05	0	696800	696800	8	68.0%		
11/12/96	6:00:05	0	696800	696800	8	68.0%		
11/12/96	7:00:05	0	699200	699200	9	68.3%		
11/12/96	8:00:05	0	699200	699200	9	68.3%		
11/12/96	9:00:06	0	699200	699200	9	68.3%		
11/12/96	10:00:05	32000	643200	675200	9	65.9%		
11/12/96	11:00:05	96000	643200	739200	11	72.2%		
11/12/96	12:00:05	0	640800	640800	7	62.6%		
11/12/96	13:00:05	0	589600	589600	4	57.6%		
11/12/96	14:00:07	32000	589600	621600	5	60.7%		
11/12/96	15:00:04	32000	589600	621600	5	60.7%		
11/12/96	16:00:05	0	589600	589600	4	57.6%		
11/12/96	17:00:05	0	589600	589600	4	57.6%		
11/12/96	18:00:04	0	589600	589600	4	57.6%		
11/12/96	19:00:05	0	589600	589600	4	57.6%		
11/12/96	20:00:05	0	589600	589600	4	57.6%		
11/12/96	21:00:04	0	589600	589600	4	57.6%		
11/12/96	22:00:05	0	589600	589600	4	57.6%		

		Ft Bragg to Hurlburt 1						
		1024K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/12/96	23:00:05	0	589600	589600	4	57.6%		
11/13/96	0:00:05	0	589600	589600	4	57.6%		
11/13/96	1:00:04	0	589600	589600	4	57.6%		
11/13/96	2:00:05	0	589600	589600	4	57.6%		
11/13/96	3:00:05	0	589600	589600	4	57.6%		
11/13/96	4:00:04	0	589600	589600	4	57.6%		
11/13/96	5:00:05	0	589600	589600	4	57.6%		
11/13/96	6:00:05	0	589600	589600	4	57.6%		
11/13/96	7:00:05	0	640800	640800	7	62.6%		
11/13/96	8:00:05	0	640800	640800	7	62.6%		
11/13/96	9:00:04	0	640800	640800	7	62.6%		
11/13/96	10:00:05	0	640800	640800	7	62.6%		
11/13/96	11:00:05	32000	640800	672800	8	65.7%		
11/13/96	12:00:04	96000	640800	736800	10	72.0%		
11/13/96	13:00:05	0	640800	640800	7	62.6%		
11/13/96	14:00:05	0	640800	640800	7	62.6%		
11/13/96	15:00:05	32000	640800	672800	8	65.7%		
11/13/96	16:00:05	32000	643200	675200	9	65.9%		
11/13/96	17:00:05	0	643200	643200	8	62.8%		
11/13/96	18:00:05	0	640800	640800	7	62.6%		
11/13/96	19:00:04	0	640800	640800	7	62.6%		
11/13/96	20:00:05	0	640800	640800	7	62.6%		
11/13/96	21:00:05	0	640800	640800	7	62.6%		
11/13/96	22:00:04	0	640800	640800	7	62.6%		
11/13/96	23:00:05	0	640800	640800	7	62.6%		
11/14/96	0:00:05	0	640800	640800	7	62.6%		
11/14/96	1:00:05	0	640800	640800	7	62.6%		
11/14/96	2:00:05	0	640800	640800	7	62.6%		
11/14/96	3:00:05	0	640800	640800	7	62.6%		
11/14/96	4:00:05	0	640800	640800	7	62.6%		
11/14/96	5:00:06	0	640800	640800	7	62.6%		
11/14/96	6:00:04	0	640800	640800	7	62.6%		
11/14/96	7:00:04	0	640800	640800	7	62.6%		
11/14/96	8:00:05	0	643200	643200	8	62.8%		
11/14/96	9:09:21	64000	643200	707200	10	69.1%		
11/14/96	10:00:05	32000	643200	675200	9	65.9%		
11/14/96	11:00:05	64000	512000	576000	3	56.3%		
11/14/96	12:00:05	64000	512000	576000	3	56.3%		
11/14/96	13:00:05	0	528000	528000	2	51.6%		
11/14/96	14:00:05	32000	605600	637600	6	62.3%		
11/14/96	15:00:05	32000	608000	640000	7	62.5%		
11/14/96	16:00:05	64000	608000	672000	8	65.6%		
11/14/96	17:00:05	0	608000	608000	6	59.4%		
11/14/96	16:00:05	0	605600	605600	5	59.1%		
11/14/96	19:00:04	0	605600	605600	5	59.1%		
11/14/96	20:00:04	0	605600	605600	5	59.1%		
11/14/96	21:00:04	0	605600	605600	5	59.1%		

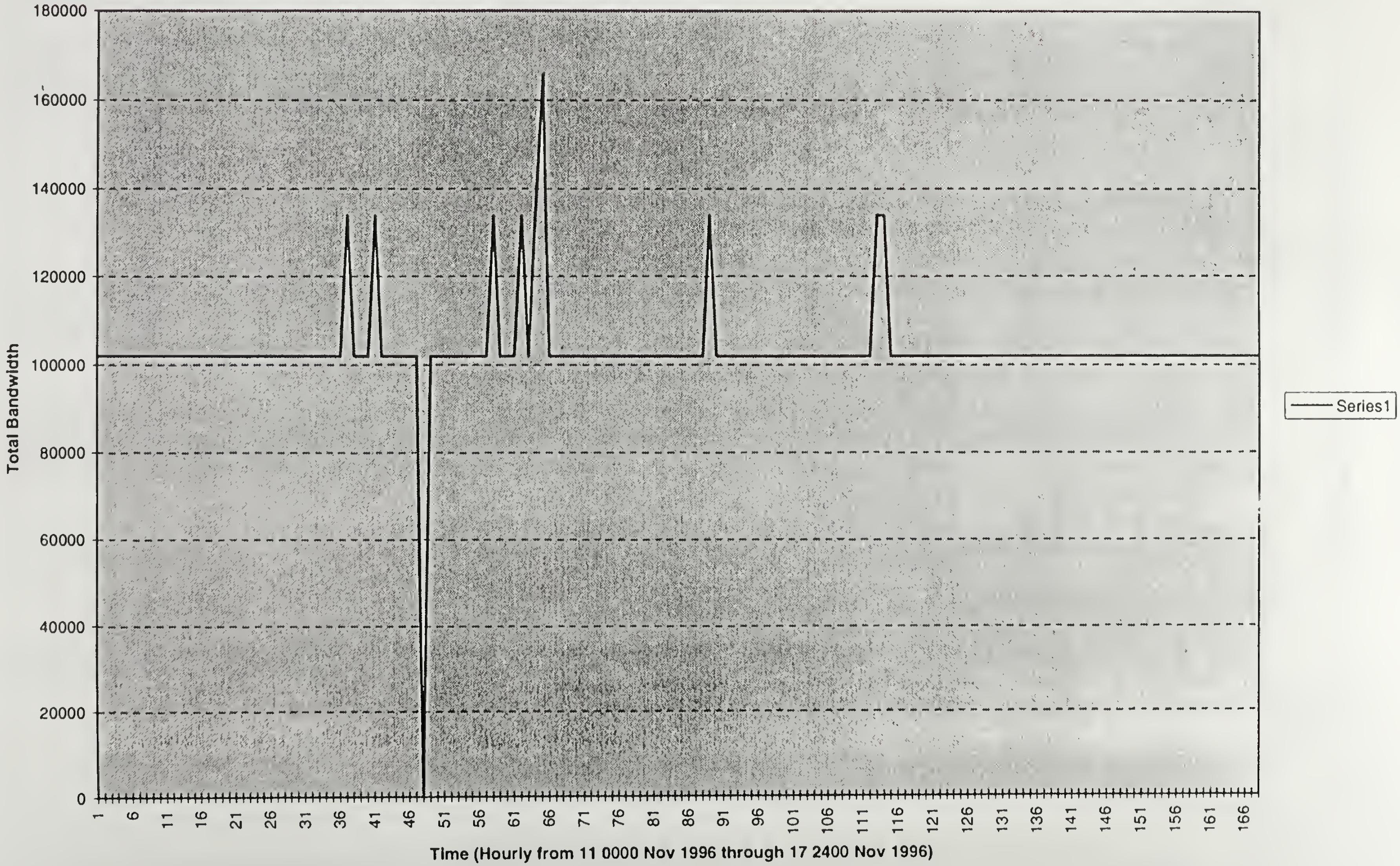
		Ft Bragg to Hurlburt 1						
		1024K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/14/96	22:00:05	0	608000	608000	6	59.4%		
11/14/96	23:00:05	0	605600	605600	5	59.1%		
11/15/96	0:00:04	0	605600	605600	5	59.1%		
11/15/96	1:00:05	0	640800	640800	7	62.6%		
11/15/96	2:00:04	0	640800	640800	7	62.6%		
11/15/96	3:00:05	0	640800	640800	7	62.6%		
11/15/96	4:00:05	0	640800	640800	7	62.6%		
11/15/96	5:00:05	0	640800	640800	7	62.6%		
11/15/96	6:00:37	0	640800	640800	7	62.6%		
11/15/96	7:00:06	0	640800	640800	7	62.6%		
11/15/96	8:00:05	0	643200	643200	8	62.8%		
11/15/96	9:00:04	64000	643200	707200	10	69.1%		
11/15/96	10:00:05	0	643200	643200	8	62.8%		
11/15/96	11:00:05	0	643200	643200	8	62.8%		
11/15/96	12:00:05	64000	643200	707200	10	69.1%		
11/15/96	13:00:05	32000	643200	675200	9	65.9%		
11/15/96	14:00:04	32000	643200	675200	9	65.9%		
11/15/96	15:00:05	32000	643200	675200	9	65.9%		
11/15/96	16:00:04	0	643200	643200	8	62.8%		
11/15/96	17:00:06	0	643200	643200	8	62.8%		
11/15/96	18:00:04	0	640800	640800	7	62.6%		
11/15/96	19:00:05	0	640800	640800	7	62.6%		
11/15/96	20:00:05	0	640800	640800	7	62.6%		
11/15/96	21:00:05	0	640800	640800	7	62.6%		
11/15/96	22:00:05	0	640800	640800	7	62.6%		
11/15/96	23:00:05	0	640800	640800	7	62.6%		
11/15/96	0:00:05	0	640800	640800	7	62.6%		
11/16/96	1:00:05	0	640800	640800	7	62.6%		
11/16/96	2:00:04	0	640800	640800	7	62.6%		
11/16/96	3:00:06	0	640800	640800	7	62.6%		
11/16/96	4:00:04	0	640800	640800	7	62.6%		
11/16/96	5:00:04	0	640800	640800	7	62.6%		
11/16/96	6:00:05	0	640800	640800	7	62.6%		
11/16/96	7:00:05	0	640800	640800	7	62.6%		
11/16/96	8:00:05	0	640800	640800	7	62.6%		
11/16/96	9:00:05	0	640800	640800	7	62.6%		
11/16/96	10:00:05	0	640800	640800	7	62.6%		
11/16/96	11:00:04	0	640800	640800	7	62.6%		
11/16/96	12:00:05	0	640800	640800	7	62.6%		
11/16/96	13:00:05	0	640800	640800	7	62.6%		
11/16/96	14:00:05	0	640800	640800	7	62.6%		
11/16/96	15:00:04	0	640800	640800	7	62.6%		
11/16/96	16:00:04	0	640800	640800	7	62.6%		
11/16/96	17:00:04	0	640800	640800	7	62.6%		
11/16/96	18:00:05	0	640800	640800	7	62.6%		
11/16/96	19:00:04	0	640800	640800	7	62.6%		
11/16/96	20:00:04	0	640800	640800	7	62.6%		

Bandwidth Utilization Report
N1N9

		Ft Bragg to Hurlburt 1						
		1024K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/16/96	21:00:05	0	640800	640800	7	62.6%		
11/16/96	22:00:04	0	640800	640800	7	62.6%		
11/16/96	23:00:05	0	640800	640800	7	62.6%		
11/17/96	0:00:04	0	640800	640800	7	62.6%		
11/17/96	1:00:04	0	640800	640800	7	62.6%		
11/17/96	2:00:05	0	640800	640800	7	62.6%		
11/17/96	3:00:05	0	640800	640800	7	62.6%		
11/17/96	4:00:05	0	640800	640800	7	62.6%		
11/17/96	5:00:04	0	640800	640800	7	62.6%		
11/17/96	6:00:04	0	640800	640800	7	62.6%		
11/17/96	7:00:05	0	640800	640800	7	62.6%		
11/17/96	8:00:05	0	640800	640800	7	62.6%		
11/17/96	9:00:05	0	640800	640800	7	62.6%		
11/17/96	10:00:05	0	640800	640800	7	62.6%		
11/17/96	11:00:04	0	640800	640800	7	62.6%		
11/17/96	12:00:05	0	640800	640800	7	62.6%		
11/17/96	13:00:04	0	640800	640800	7	62.6%		
11/17/96	14:00:04	0	696800	696800	8	68.0%		
11/17/96	15:00:05	0	696800	696800	8	68.0%		
11/17/96	16:00:13	0	696800	696800	8	68.0%		
11/17/96	17:00:05	0	696800	696800	8	68.0%		
11/17/96	18:00:05	0	696800	696800	8	68.0%		
11/17/96	19:00:04	0	696800	696800	8	68.0%		
11/17/96	20:00:05	0	696800	696800	8	68.0%		
11/17/96	21:00:05	0	696800	696800	8	68.0%		
11/17/96	22:00:05	0	696800	696800	8	68.0%		
11/17/96	23:00:05	0	696800	696800	8	68.0%		

N1N8 Chart 1

Ft Bragg to Hunter - 384K



Bandwidth Utilization Report
N1N8

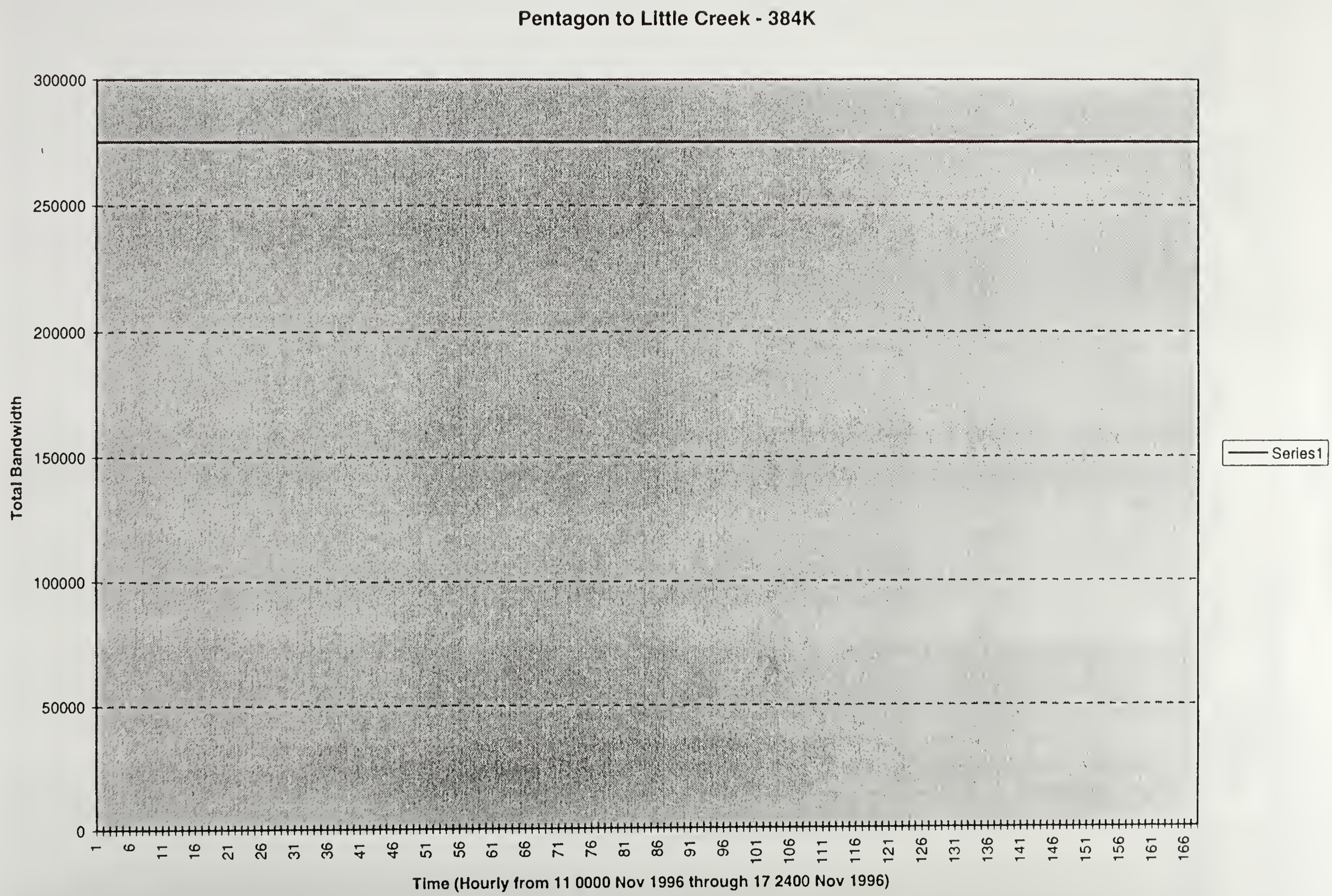
		Ft Bragg to Hunter						
		384K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/11/96	0:00:02	0	101943	101943	4	26.5%	26.9%	11546.32
11/11/96	1:00:02	0	101943	101943	4	26.5%		
11/11/96	2:00:03	0	101943	101943	4	26.5%		
11/11/96	3:00:03	0	101943	101943	4	26.5%	**Average**	**Median**
11/11/96	4:00:03	0	101943	101943	4	26.5%	103241	101943
11/11/96	5:00:03	0	101943	101943	4	26.5%		
11/11/96	6:00:03	0	101943	101943	4	26.5%		
11/11/96	7:00:03	0	101943	101943	4	26.5%		
11/11/96	8:00:03	0	101943	101943	4	26.5%		
11/11/96	9:00:02	0	101943	101943	4	26.5%		
11/11/96	10:00:03	0	101943	101943	4	26.5%		
11/11/96	11:00:03	0	101943	101943	4	26.5%		
11/11/96	12:00:03	0	101943	101943	4	26.5%		
11/11/96	13:00:03	0	101943	101943	4	26.5%		
11/11/96	14:00:03	0	101943	101943	4	26.5%		
11/11/96	15:00:03	0	101943	101943	4	26.5%		
11/11/96	16:00:02	0	101943	101943	4	26.5%		
11/11/96	17:00:02	0	101943	101943	4	26.5%		
11/11/96	18:00:03	0	101943	101943	4	26.5%		
11/11/96	19:00:02	0	101943	101943	4	26.5%		
11/11/96	20:00:02	0	101943	101943	4	26.5%		
11/11/96	21:00:03	0	101943	101943	4	26.5%		
11/11/96	22:00:03	0	101943	101943	4	26.5%		
11/11/96	23:00:03	0	101943	101943	4	26.5%		
11/12/96	0:00:03	0	101943	101943	4	26.5%		
11/12/96	1:00:02	0	101943	101943	4	26.5%		
11/12/96	2:00:03	0	101943	101943	4	26.5%		
11/12/96	3:00:03	0	101943	101943	4	26.5%		
11/12/96	4:00:02	0	101943	101943	4	26.5%		
11/12/96	5:00:03	0	101943	101943	4	26.5%		
11/12/96	6:00:03	0	101943	101943	4	26.5%		
11/12/96	7:00:03	0	101943	101943	4	26.5%		
11/12/96	8:00:03	0	101943	101943	4	26.5%		
11/12/96	9:00:04	0	101943	101943	4	26.5%		
11/12/96	10:00:03	0	101943	101943	4	26.5%		
11/12/96	11:00:03	0	101943	101943	4	26.5%		
11/12/96	12:00:03	32000	101943	133943	5	34.9%		
11/12/96	13:00:04	0	101943	101943	4	26.5%		
11/12/96	14:00:04	0	101943	101943	4	26.5%		
11/12/96	15:00:02	0	101943	101943	4	26.5%		
11/12/96	16:00:03	32000	101943	133943	5	34.9%		
11/12/96	17:00:03	0	101943	101943	4	26.5%		
11/12/96	18:00:02	0	101943	101943	4	26.5%		
11/12/96	19:00:03	0	101943	101943	4	26.5%		
11/12/96	20:00:03	0	101943	101943	4	26.5%		
11/12/96	21:00:02	0	101943	101943	4	26.5%		
11/12/96	22:00:03	0	101943	101943	4	26.5%		

Bandwidth Utilization Report
N1N8

		Ft Bragg to Hunter						
		384K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/12/96	23:00:03	0	0	0	0	0.0%		
11/13/96	0:00:03	0	101943	101943	4	26.5%		
11/13/96	1:00:02	0	101943	101943	4	26.5%		
11/13/96	2:00:03	0	101943	101943	4	26.5%		
11/13/96	3:00:03	0	101943	101943	4	26.5%		
11/13/96	4:00:02	0	101943	101943	4	26.5%		
11/13/96	5:00:03	0	101943	101943	4	26.5%		
11/13/96	6:00:03	0	101943	101943	4	26.5%		
11/13/96	7:00:03	0	101943	101943	4	26.5%		
11/13/96	8:00:04	0	101943	101943	4	26.5%		
11/13/96	9:00:02	32000	101943	133943	5	34.9%		
11/13/96	10:00:03	0	101943	101943	4	26.5%		
11/13/96	11:00:03	0	101943	101943	4	26.5%		
11/13/96	12:00:03	0	101943	101943	4	26.5%		
11/13/96	13:00:03	32000	101943	133943	5	34.9%		
11/13/96	14:00:03	0	101943	101943	4	26.5%		
11/13/96	15:00:03	32000	101943	133943	5	34.9%		
11/13/96	16:00:03	64000	101943	165943	6	43.2%		
11/13/96	17:00:03	0	101943	101943	4	26.5%		
11/13/96	18:00:03	0	101943	101943	4	26.5%		
11/13/96	19:00:03	0	101943	101943	4	26.5%		
11/13/96	20:00:03	0	101943	101943	4	26.5%		
11/13/96	21:00:03	0	101943	101943	4	26.5%		
11/13/96	22:00:03	0	101943	101943	4	26.5%		
11/13/96	23:00:03	0	101943	101943	4	26.5%		
11/14/96	0:00:03	0	101943	101943	4	26.5%		
11/14/96	1:00:03	0	101943	101943	4	26.5%		
11/14/96	2:00:03	0	101943	101943	4	26.5%		
11/14/96	3:00:03	0	101943	101943	4	26.5%		
11/14/96	4:00:03	0	101943	101943	4	26.5%		
11/14/96	5:00:04	0	101943	101943	4	26.5%		
11/14/96	6:00:02	0	101943	101943	4	26.5%		
11/14/96	7:00:02	0	101943	101943	4	26.5%		
11/14/96	8:00:03	0	101943	101943	4	26.5%		
11/14/96	9:09:14	0	101943	101943	4	26.5%		
11/14/96	10:00:03	0	101943	101943	4	26.5%		
11/14/96	11:00:03	0	101943	101943	4	26.5%		
11/14/96	12:00:03	0	101943	101943	4	26.5%		
11/14/96	13:00:03	0	101943	101943	4	26.5%		
11/14/96	14:00:03	0	101943	101943	4	26.5%		
11/14/96	15:00:03	0	101943	101943	4	26.5%		
11/14/96	16:00:03	32000	101943	133943	5	34.9%		
11/14/96	17:00:03	0	101943	101943	4	26.5%		
11/14/96	18:00:03	0	101943	101943	4	26.5%		
11/14/96	19:00:02	0	101943	101943	4	26.5%		
11/14/96	20:00:02	0	101943	101943	4	26.5%		
11/14/96	21:00:03	0	101943	101943	4	26.5%		

		Ft Bragg to Hunter						
		384K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/14/96	22:00:03	0	101943	101943	4	26.5%		
11/14/96	23:00:03	0	101943	101943	4	26.5%		
11/15/96	0:00:03	0	101943	101943	4	26.5%		
11/15/96	1:00:03	0	101943	101943	4	26.5%		
11/15/96	2:00:03	0	101943	101943	4	26.5%		
11/15/96	3:00:02	0	101943	101943	4	26.5%		
11/15/96	4:00:03	0	101943	101943	4	26.5%		
11/15/96	5:00:03	0	101943	101943	4	26.5%		
11/15/96	6:00:35	0	101943	101943	4	26.5%		
11/15/96	7:00:04	0	101943	101943	4	26.5%		
11/15/96	8:00:04	0	101943	101943	4	26.5%		
11/15/96	9:00:02	0	101943	101943	4	26.5%		
11/15/96	10:00:03	0	101943	101943	4	26.5%		
11/15/96	11:00:03	0	101943	101943	4	26.5%		
11/15/96	12:00:03	0	101943	101943	4	26.5%		
11/15/96	13:00:03	0	101943	101943	4	26.5%		
11/15/96	14:00:02	0	101943	101943	4	26.5%		
11/15/96	15:00:03	0	101943	101943	4	26.5%		
11/15/96	16:00:02	32000	101943	133943	5	34.9%		
11/15/96	17:00:04	32000	101943	133943	5	34.9%		
11/15/96	18:00:03	0	101943	101943	4	26.5%		
11/15/96	19:00:03	0	101943	101943	4	26.5%		
11/15/96	20:00:03	0	101943	101943	4	26.5%		
11/15/96	21:00:03	0	101943	101943	4	26.5%		
11/15/96	22:00:03	0	101943	101943	4	26.5%		
11/15/96	23:00:03	0	101943	101943	4	26.5%		
11/15/96	0:00:03	0	101943	101943	4	26.5%		
11/16/96	1:00:03	0	101943	101943	4	26.5%		
11/16/96	2:00:03	0	101943	101943	4	26.5%		
11/16/96	3:00:04	0	101943	101943	4	26.5%		
11/16/96	4:00:03	0	101943	101943	4	26.5%		
11/16/96	5:00:02	0	101943	101943	4	26.5%		
11/16/96	6:00:03	0	101943	101943	4	26.5%		
11/16/96	7:00:03	0	101943	101943	4	26.5%		
11/16/96	8:00:03	0	101943	101943	4	26.5%		
11/16/96	9:00:03	0	101943	101943	4	26.5%		
11/16/96	10:00:03	0	101943	101943	4	26.5%		
11/16/96	11:00:02	0	101943	101943	4	26.5%		
11/16/96	12:00:03	0	101943	101943	4	26.5%		
11/16/96	13:00:03	0	101943	101943	4	26.5%		
11/16/96	14:00:03	0	101943	101943	4	26.5%		
11/16/96	15:00:03	0	101943	101943	4	26.5%		
11/16/96	16:00:02	0	101943	101943	4	26.5%		
11/16/96	17:00:02	0	101943	101943	4	26.5%		
11/16/96	18:00:03	0	101943	101943	4	26.5%		
11/16/96	19:00:03	0	101943	101943	4	26.5%		
11/16/96	20:00:03	0	101943	101943	4	26.5%		

N6N19 Chart 1



		Pentagon to Little Creek						
		384K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/11/96	0:00:08	0	275200	275200	2	71.7%	71.7%	0
11/11/96	1:00:08	0	275200	275200	2	71.7%		
11/11/96	2:00:08	0	275200	275200	2	71.7%		
11/11/96	3:00:08	0	275200	275200	2	71.7%	Average	Median
11/11/96	4:00:08	0	275200	275200	2	71.7%	275200	275200
11/11/96	5:00:08	0	275200	275200	2	71.7%		
11/11/96	6:00:08	0	275200	275200	2	71.7%		
11/11/96	7:00:08	0	275200	275200	2	71.7%		
11/11/96	8:00:08	0	275200	275200	2	71.7%		
11/11/96	9:00:07	0	275200	275200	2	71.7%		
11/11/96	10:00:08	0	275200	275200	2	71.7%		
11/11/96	11:00:09	0	275200	275200	2	71.7%		
11/11/96	12:00:08	0	275200	275200	2	71.7%		
11/11/96	13:00:08	0	275200	275200	2	71.7%		
11/11/96	14:00:08	0	275200	275200	2	71.7%		
11/11/96	15:00:08	0	275200	275200	2	71.7%		
11/11/96	16:00:08	0	275200	275200	2	71.7%		
11/11/96	17:00:08	0	275200	275200	2	71.7%		
11/11/96	18:00:08	0	275200	275200	2	71.7%		
11/11/96	19:00:08	0	275200	275200	2	71.7%		
11/11/96	20:00:08	0	275200	275200	2	71.7%		
11/11/96	21:00:08	0	275200	275200	2	71.7%		
11/11/96	22:00:08	0	275200	275200	2	71.7%		
11/11/96	23:00:08	0	275200	275200	2	71.7%		
11/12/96	0:00:08	0	275200	275200	2	71.7%		
11/12/96	1:00:08	0	275200	275200	2	71.7%		
11/12/96	2:00:08	0	275200	275200	2	71.7%		
11/12/96	3:00:08	0	275200	275200	2	71.7%		
11/12/96	4:00:07	0	275200	275200	2	71.7%		
11/12/96	5:00:08	0	275200	275200	2	71.7%		
11/12/96	6:00:09	0	275200	275200	2	71.7%		
11/12/96	7:00:08	0	275200	275200	2	71.7%		
11/12/96	8:00:08	0	275200	275200	2	71.7%		
11/12/96	9:00:41	0	275200	275200	2	71.7%		
11/12/96	10:00:08	0	275200	275200	2	71.7%		
11/12/96	11:00:08	0	275200	275200	2	71.7%		
11/12/96	12:00:08	0	275200	275200	2	71.7%		
11/12/96	13:00:08	0	275200	275200	2	71.7%		
11/12/96	14:00:11	0	275200	275200	2	71.7%		
11/12/96	15:00:08	0	275200	275200	2	71.7%		
11/12/96	16:00:08	0	275200	275200	2	71.7%		
11/12/96	17:00:08	0	275200	275200	2	71.7%		
11/12/96	18:00:08	0	275200	275200	2	71.7%		
11/12/96	19:00:08	0	275200	275200	2	71.7%		
11/12/96	20:00:09	0	275200	275200	2	71.7%		
11/12/96	21:00:07	0	275200	275200	2	71.7%		
11/12/96	22:00:08	0	275200	275200	2	71.7%		

		Pentagon to Little Creek						
		384K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/12/96	23:00:09	0	275200	275200	2	71.7%		
11/13/96	0:00:08	0	275200	275200	2	71.7%		
11/13/96	1:00:08	0	275200	275200	2	71.7%		
11/13/96	2:00:08	0	275200	275200	2	71.7%		
11/13/96	3:00:08	0	275200	275200	2	71.7%		
11/13/96	4:00:08	0	275200	275200	2	71.7%		
11/13/96	5:00:08	0	275200	275200	2	71.7%		
11/13/96	6:00:08	0	275200	275200	2	71.7%		
11/13/96	7:00:08	0	275200	275200	2	71.7%		
11/13/96	8:00:09	0	275200	275200	2	71.7%		
11/13/96	9:00:07	0	275200	275200	2	71.7%		
11/13/96	10:00:08	0	275200	275200	2	71.7%		
11/13/96	11:00:08	0	275200	275200	2	71.7%		
11/13/96	12:00:08	0	275200	275200	2	71.7%		
11/13/96	13:00:09	0	275200	275200	2	71.7%		
11/13/96	14:00:08	0	275200	275200	2	71.7%		
11/13/96	15:00:08	0	275200	275200	2	71.7%		
11/13/96	16:00:08	0	275200	275200	2	71.7%		
11/13/96	17:00:09	0	275200	275200	2	71.7%		
11/13/96	18:00:08	0	275200	275200	2	71.7%		
11/13/96	19:00:08	0	275200	275200	2	71.7%		
11/13/96	20:00:08	0	275200	275200	2	71.7%		
11/13/96	21:00:08	0	275200	275200	2	71.7%		
11/13/96	22:00:08	0	275200	275200	2	71.7%		
11/13/96	23:00:08	0	275200	275200	2	71.7%		
11/14/96	0:00:08	0	275200	275200	2	71.7%		
11/14/96	1:00:08	0	275200	275200	2	71.7%		
11/14/96	2:00:08	0	275200	275200	2	71.7%		
11/14/96	3:00:08	0	275200	275200	2	71.7%		
11/14/96	4:00:09	0	275200	275200	2	71.7%		
11/14/96	5:00:11	0	275200	275200	2	71.7%		
11/14/96	6:00:08	0	275200	275200	2	71.7%		
11/14/96	7:00:07	0	275200	275200	2	71.7%		
11/14/96	8:00:08	0	275200	275200	2	71.7%		
11/14/96	9:09:29	0	275200	275200	2	71.7%		
11/14/96	10:00:08	0	275200	275200	2	71.7%		
11/14/96	11:00:08	0	275200	275200	2	71.7%		
11/14/96	12:00:08	0	275200	275200	2	71.7%		
11/14/96	13:00:08	0	275200	275200	2	71.7%		
11/14/96	14:00:08	0	275200	275200	2	71.7%		
11/14/96	15:00:08	0	275200	275200	2	71.7%		
11/14/96	16:00:08	0	275200	275200	2	71.7%		
11/14/96	17:00:09	0	275200	275200	2	71.7%		
11/14/96	18:00:08	0	275200	275200	2	71.7%		
11/14/96	19:00:07	0	275200	275200	2	71.7%		
11/14/96	20:00:07	0	275200	275200	2	71.7%		
11/14/96	21:00:08	0	275200	275200	2	71.7%		

		Pentagon to Little Creek 384K						
Date mm/dd/yy	Time hh:mm:ss	Voice Bandwidth	Data Bandwidth	Total Bandwidth	Total Calls	Percent Bandwidth	Average Percent Bandwidth	Standard Deviation
11/14/96	22:00:08	0	275200	275200	2	71.7%		
11/14/96	23:00:09	0	275200	275200	2	71.7%		
11/15/96	0:01:13	0	275200	275200	2	71.7%		
11/15/96	1:00:08	0	275200	275200	2	71.7%		
11/15/96	2:00:08	0	275200	275200	2	71.7%		
11/15/96	3:00:08	0	275200	275200	2	71.7%		
11/15/96	4:00:10	0	275200	275200	2	71.7%		
11/15/96	5:00:08	0	275200	275200	2	71.7%		
11/15/96	6:00:41	0	275200	275200	2	71.7%		
11/15/96	7:00:09	0	275200	275200	2	71.7%		
11/15/96	8:00:09	0	275200	275200	2	71.7%		
11/15/96	9:00:08	0	275200	275200	2	71.7%		
11/15/96	10:00:08	0	275200	275200	2	71.7%		
11/15/96	11:00:08	0	275200	275200	2	71.7%		
11/15/96	12:00:09	0	275200	275200	2	71.7%		
11/15/96	13:00:08	0	275200	275200	2	71.7%		
11/15/96	14:00:07	0	275200	275200	2	71.7%		
11/15/96	15:00:08	0	275200	275200	2	71.7%		
11/15/96	16:00:08	0	275200	275200	2	71.7%		
11/15/96	17:00:09	0	275200	275200	2	71.7%		
11/15/96	18:00:08	0	275200	275200	2	71.7%		
11/15/96	19:00:08	0	275200	275200	2	71.7%		
11/15/96	20:00:09	0	275200	275200	2	71.7%		
11/15/96	21:00:08	0	275200	275200	2	71.7%		
11/15/96	22:00:08	0	275200	275200	2	71.7%		
11/15/96	23:00:08	0	275200	275200	2	71.7%		
11/15/96	0:00:08	0	275200	275200	2	71.7%		
11/16/96	1:00:08	0	275200	275200	2	71.7%		
11/16/96	2:00:08	0	275200	275200	2	71.7%		
11/16/96	3:00:09	0	275200	275200	2	71.7%		
11/16/96	4:00:08	0	275200	275200	2	71.7%		
11/16/96	5:00:08	0	275200	275200	2	71.7%		
11/16/96	6:00:08	0	275200	275200	2	71.7%		
11/16/96	7:00:08	0	275200	275200	2	71.7%		
11/16/96	8:00:08	0	275200	275200	2	71.7%		
11/16/96	9:00:08	0	275200	275200	2	71.7%		
11/16/96	10:00:08	0	275200	275200	2	71.7%		
11/16/96	11:00:07	0	275200	275200	2	71.7%		
11/16/96	12:00:08	0	275200	275200	2	71.7%		
11/16/96	13:00:08	0	275200	275200	2	71.7%		
11/16/96	14:00:08	0	275200	275200	2	71.7%		
11/16/96	15:00:08	0	275200	275200	2	71.7%		
11/16/96	16:00:08	0	275200	275200	2	71.7%		
11/16/96	17:00:08	0	275200	275200	2	71.7%		
11/16/96	18:00:08	0	275200	275200	2	71.7%		
11/16/96	19:00:08	0	275200	275200	2	71.7%		
11/16/96	20:00:08	0	275200	275200	2	71.7%		

Bandwidth Utilization Report
N6N19

		Pentagon to Little Creek						
		384K					Average	
Date	Time	Voice	Data	Total	Total	Percent	Percent	Standard
mm/dd/yy	hh:mm:ss	Bandwidth	Bandwidth	Bandwidth	Calls	Bandwidth	Bandwidth	Deviation
11/16/96	21:00:08	0	275200	275200	2	71.7%		
11/16/96	22:00:25	0	275200	275200	2	71.7%		
11/16/96	23:00:08	0	275200	275200	2	71.7%		
11/17/96	0:00:08	0	275200	275200	2	71.7%		
11/17/96	1:00:08	0	275200	275200	2	71.7%		
11/17/96	2:00:08	0	275200	275200	2	71.7%		
11/17/96	3:00:08	0	275200	275200	2	71.7%		
11/17/96	4:00:09	0	275200	275200	2	71.7%		
11/17/96	5:00:08	0	275200	275200	2	71.7%		
11/17/96	6:00:08	0	275200	275200	2	71.7%		
11/17/96	7:00:08	0	275200	275200	2	71.7%		
11/17/96	8:00:08	0	275200	275200	2	71.7%		
11/17/96	9:00:08	0	275200	275200	2	71.7%		
11/17/96	10:00:08	0	275200	275200	2	71.7%		
11/17/96	11:00:08	0	275200	275200	2	71.7%		
11/17/96	12:00:08	0	275200	275200	2	71.7%		
11/17/96	13:00:10	0	275200	275200	2	71.7%		
11/17/96	14:00:08	0	275200	275200	2	71.7%		
11/17/96	15:00:08	0	275200	275200	2	71.7%		
11/17/96	16:00:16	0	275200	275200	2	71.7%		
11/17/96	17:00:08	0	275200	275200	2	71.7%		
11/17/96	18:00:08	0	275200	275200	2	71.7%		
11/17/96	19:00:08	0	275200	275200	2	71.7%		
11/17/96	20:00:08	0	275200	275200	2	71.7%		
11/17/96	21:00:08	0	275200	275200	2	71.7%		
11/17/96	22:00:08	0	275200	275200	2	71.7%		
11/17/96	23:00:08	0	275200	275200	2	71.7%		

APPENDIX B. NETWORK MANAGEMENT DEFINITIONS

There are many sub-definitions for some of the following terms. The author has attempted to use the most relevant definition to the subject matter in the thesis.

Agent

Software running on a network device or computer system which collects and makes available MIB variables

Application Program Interface (API)

A term for the interface by which an application program gains access to an NMS (or other software service), usually defined at the source code level. An example is the JAVA Management API (MAPI).

Abstract Syntax Notation One (ASN.1)

The OSI language for describing abstract entities by using macros that build on simpler entities. The primary advantage of this syntax is that it is not dependent upon the underlying hardware.

Asynchronous Transfer Mode (ATM)

A high speed connection oriented switching and multiplexing technology that uses 53 byte cells (5 byte header, 48 byte payload) to transmit different types of traffic simultaneously, including voice, video and data. It is asynchronous in that information streams can be sent independently without a common clock.

Autodiscovery

The process of automatically locating objects on the network. Some autodiscovery algorithms also determine and save the network topology. Usually access is limited to "community strings" which only allow operation within a named network section.

Binary 8 Zero Substitution (B8ZS)

A technique that accommodates the ones-density requirement of digital public transmission facilities, without inducing bit errors.

Bandwidth

The amount of traffic capacity the transmission media can support at one time. Applications are increasingly requiring more and more bandwidth.

Client/Server

An architecture for network services in which a central processor (the server) runs programs that provide file storage, database management and access to shared resources, while a number of remote users run "client" software designed to access and share these resources. In network management terms, the server would service clients within a sphere of responsibility with those management tasks and functions relevant to its operation.

Common Management Information Protocol (CMIP)

Common Management Information Protocol, an application level protocol, specified by OSI, for network management.

Customer Network Management (CNM)

Customer Network Management, this provides (business) customers with access to management information in the public network management system. This management information relates to services provided to the customer by the service provider.

Dynamic Host Configuration Protocol (DHCP)

Dynamic Host Configuration Protocol. Used to dynamically assign IP addresses.

Element Management System (EMS)

An EMS manages a specific portion of the network. For example with a SunNet Manager, an SNMP management application, is used to manage SNMP manageable elements. Element Managers may manage async lines, multiplexers, PABX's, proprietary systems or an application.

Fault Management

Fault management is the detection of a problem, fault isolation and correction to normal operation.

Integrated Services Digital Network (ISDN)

- A switched digital transmission service provided by a local telco's switching office. Uses same copper as analog service so is practical for home, small office, school applications. Available in BRI (2 64Kb data channels 1 signaling channel) or PRI (23 bearer(data/voice) channels 1 signaling channel)

Internet Protocol (IP)

A layer 3 protocol, part of the TCP/IP protocol suite that governs packet forwarding between LAN's or LAN segments.

Jabber

A blanket term for a device that is behaving improperly in terms of electrical signaling on a network. In ethernet this is Very Bad, because ethernet uses electrical signal levels to determine whether the network is available for transmission. A jabbering device can cause the entire network to halt because all other devices think it is busy. Without protocol and application monitoring this problem may not be detected.

Local Area Network (LAN)

A data-communications system that operates within a building or "campus". This meaning has been somewhat diluted due to extensions of LAN range. A LAN can serve a base and still be referred to as a LAN rather than a WAN.

Managed Objects

Managed Objects are the devices, systems and/or anything else, e.g., protocols or applications requiring some form of monitoring and management.

Management Information Base (MIB)

The objects that are available in a managed system. The information is represented in Abstract Syntax Notation 1 (ASN.1)

MIB Browser

A software tool that can be used to display arbitrary MIB variables obtained from an SNMP agent, allowing the user to browse through all the information provided about the device or service supported by the agent.

Open Systems Foundation (OSF)

A foundation created by nine computer vendors to promote Open Computing. It is planned that common operating systems and interfaces, based on developments in Unix, the X Windows System, etc. will be forthcoming for a wide range of different hardware architectures.

Open Systems Interconnection (OSI)

A top-level model of network architecture that specified seven functional layers. (Applications using modern programming often bypasses these artificial layers and lets high level applications perform functions that were reserved for lower level functionality.)

Request For Comment (RFC)

The realization that standards in the computer industry change very quickly has resulted in a defacto publishing of RFC's to allow computer industry providers the ability to try and shape a moving target of standardization by publishing and commenting on the proposed rules. Usually obsolete by the time the RFC is widely read and initially adhered to by the group.

Simple Network Management Protocol (SNMP)

An application layer protocol that allows remote management of networked devices. A defacto standard for setting and monitoring network configuration parameters. Currently the version is SNMPv2 and work is proceeding on a subsequent improvement.

TRAP

A trap is an unsolicited (device initiated) message. The contents of the message might be simply informational, but it is mostly used to report real-time alarm information.

Virtual Private Network (VPN)

The use of a public network such as the Internet in place of private lines to transport internal corporate data such as intranet documents, groupware communications and email.

Wide Area Network (WAN)

A public or private communications system serving geographically separate areas.

APPENDIX C. BIBLIOGRAPHY OF NMS REFERENCES

This bibliography is provided to given a quick reference to NMS sources reviewed but not directly cited in this thesis effort. Any sources over 5 years in age are presented only because they are classic efforts in the field.

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APPENDIX D. HYPER-TEXT LINKS TO NMS/METRIC SITES

One of the fundamental aspects of HTTP links is that they are dynamic. Their addresses, content and appearances change as often as they are updated. Any researcher, network engineer using them should recognize the necessity to monitor changes and updates. This collection while current at the time of writing will change. Not all of these are easily found in search engines on the web and represent many cross searches and browsing hours. It is hoped that this "starting point" will save valuable time for network engineers and administrators. The sites are divided into military, industry and university groups.

A. MILITARY:

AETC NMS Server.
The USAF Air Education Training Command Base Network Control Center Information Services
http://www.aetc.af.mil/AETC-NetMgmt/nms-mainmenu.html

B. INDUSTRY:

Network Management Server (NMS)
This server functions as the archive base for Network Management Systems. It is a good starting point for research.
http://netman.cit.buffalo.edu/index.html

Network Management Forum
The Network Management Forum exists to promote the worldwide acceptance and implementation of a service-based approach to network and systems management that crosses the boundaries of the telecommunications and computing industries.
http://www/nmf.org/

Management Information (European - Micromuse).
A good European Network Management resource
http://www.micromuse.com/netman/

C. UNIVERSITIES:

University of Braunschweig (Germany)
http://tu-bs.de/ibr/projects/nm/welcome.html

University of Delft (Netherlands)
http://dnpap.et.tudelft.nl/DNPAP/dnpap.html

University of Kansas NTS Network Management Homepage
Features real time network utilization statistics, subnet tables, and router arp tables for many of the educational institutions in Kansas.
http:// www.uks.edu/NMS/initial.html

Ohio State University
This site in addition to giving links to the Ohio State NMS gives a FAQ on SNMP that is good for network engineers.
http://www.cis.ohio-state.edi/htpertext/faq/usenet/snmp-faq/part1/faq.html

Stanford Linear Accelerator Center (SLAC) at Stanford
SLAC Network Management Team
http://www.slac.stanford.edu/comp/net/quick-guide.html

University of Twente (Netherlands)
Publishes *The Simple Web*, e-zine with focus on Internet management
http://snmp.cs.utwente.nl/

Yale
Distributed Management System (DMS)
http://pantheon.cis.yale.edu/~Kmyles/AS-dms.html

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Note: all http cites were reviewed for currency 6/1/97, due to the temporary nature of Internet WEB content, some sites may not contain the same links in the future.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center 8725 John J. Kingman Rd., STE 0944 Ft. Belvoir, VA 22060-6218	2
2.	Dudley Knox Library Naval Postgraduate School 411 Dyer Rd. Monterey, CA 93943-5101	2
3.	United States Special Operations Command USSOCOM J-6 7701 Tampa Pt. Blvd MacDill AFB, FL 33621-5323	3
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